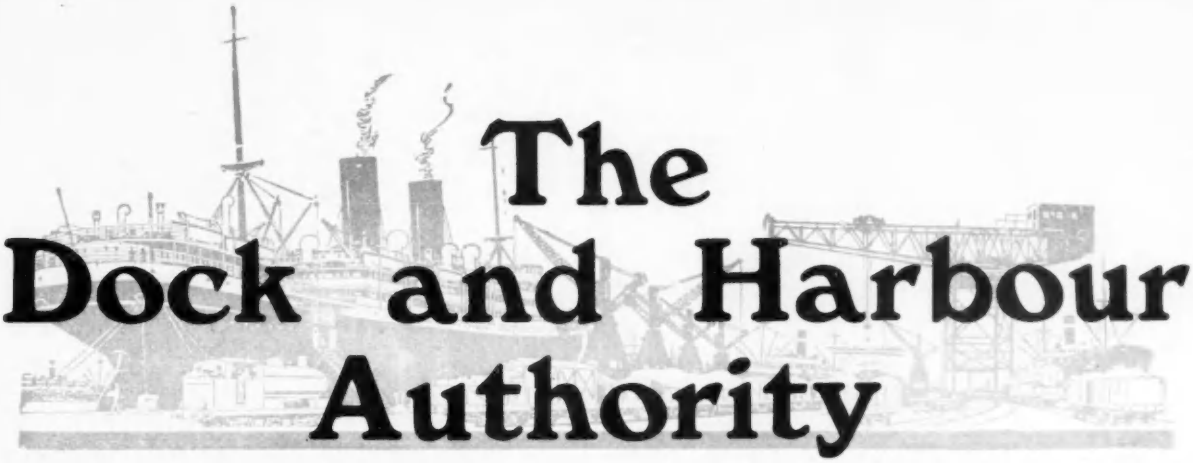

The Dock and Harbour Authority

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CONTENTS

EDITORIAL	71	THE LATE SIR JOSEPH BROODBANK	82
THE PORT OF GENOA	73	CORRESPONDENCE	82
THE HYDRAULIC SYSTEM OF OPERATION AS APPLIED TO DOCK MACHINERY	76	RETAINING WALLS	83
THE INSTITUTE OF TRANSPORT	80	OBITUARY	86
NOTES OF THE MONTH	81	THE CONSTRUCTION OF JETTIES IN EXPOSED ROADSTEADS	87
MINISTRY OF TOWN & COUNTRY PLANNING	82	PORT AND CITY OF HULL	92

Editorial Comments

Genoa and its Maritime Station.

Genoa, the second port of Italy, the history of which through the centuries is reviewed by Mr. F. C. Bowen in this issue, occupies a position of outstanding importance at the head of the gulf of the same name, which constitutes a semi-circular indentation of the Ligurian coastline. The port has been on several occasions the subject of detailed notice in this Journal, when the striking developments and improvements carried out during recent years have been described and illustrated. The last occasion was in our issue of June, 1937, when a very full account was given by Ing. Dott. Ariberto Albertazzi, the Director of Port Works, of the operations then in progress for the construction of Graving Dock No. IV, with a length of 350 metres, a width of 40 metres and a depth over sill of 13 metres. Subsequent thereto, the dock was put into commission and so continued until the outbreak of the present war, during which period it, no doubt, proved its usefulness many times in accommodating the *Rex*, the *Roma*, the *Biancomano* and other large Atlantic liners, when repairs or overhaul became necessary.

What has since happened, not only to this fine graving dock, but also to the palatial new Maritime Station at the Ponte dei Mille, described in the issue of March, 1937, to the large Benito Mussolini basin system and to a number of other modern installations in the harbour, can only be a matter of conjecture, but we very much fear that the repeated bombardments by Allied naval vessels and bombing attacks by the Royal Air Force must have played havoc with them and that little can remain, at any rate in a condition of effective utility. It is impossible to refrain from a feeling of regret, notwithstanding the compelling nature of these actions, that the admirable and costly plans for the development of the port, executed with so much skill and energy by Commendatore Albertazzi, should have suffered so disastrous a fate. It had been our privilege on several occasions during the decade of the thirties to visit the works in progress and we could not fail to admire the impressive magnificence of the structure erected by the Port Consortium for the reception of seafaring travellers, and the amplitude of the accommodation for shipping. It is to be hoped that the damage done is not altogether irreparable, but that in a relatively short period after the conclusion of hostilities, the Port of Genoa may be able to resume its activities and once more take the place in the overseas commerce of Italy, to which, as the birthplace of Columbus, it is entitled, both by tradition and long service.

The Maritime Station on the Ponte dei Mille, with its annexe on the Andrea Doria Pier, is so noteworthy that it calls for a passing remark: it must have been familiar to thousands of transatlantic travellers. Approached from the city by an overhead viaduct, 350-ft. long, from the public square in front of the main railway station, the entrance led into a capacious public concourse hall, octagonal in form and surmounted by a cupola, from which, through various corridors, access was obtained to waiting rooms, writing rooms, the restaurant, passport and baggage examination rooms and the various steamship companies' offices. It was a fine example of compact and commodious design; architecturally attractive and artistically decorated. Now it may be nothing more than a heap of rubble.

Cherbourg.

The probable fate of the Stazione Marittima at Genoa has undoubtedly been actually experienced by the equally ornate structure at Cherbourg, photographs of which, taken after the capture of the port, show its principal architectural features in a state of ruin. It was opened in July, 1933, with imposing ceremonial by the President of the French Republic. The main edifice, located on a substantial mole or jetty in a depth of water of 33 to 36 feet, is (or was) a handsome double-storey structure, in the centre of which, on the upper floor, was the main concourse or waiting hall, flanked by pavilions on each side, forming portals of honour, and surmounted by lofty turrets. On one of the pavilions was erected to a height of 220 feet, a campanile, or clock tower, which formed a notable architectural feature and was visible at a distance of 15 miles out at sea.

A novel and interesting feature of the quay front was the set of nine movable bascule gangways, now completely wrecked, which served for the transfer of passengers and their baggage from the deck of the vessel alongside the quay to the upper floor of the maritime station. These immense articulated appliances had a length of about 100 feet and an internal width of 12½ feet, divided longitudinally, so as to give a footway alongside a movable belt for hand luggage. To allow of the passage along the quay of the electric quay cranes (of capacities ranging from 3 to 15 tons) the gangways had to be lifted when not in use. The cost of the maritime station amounted to more than half a million sterling.

Cherbourg possesses a magnificent outer harbour, or roadstead, of 3,600 acres, enclosed by a massive breakwater, the initial design of which is attributed to the distinguished French engineer, Vauban. It was begun in the reign of Louis XVI and its execution was resumed by Napoleon I. Finally completed by Napoleon III, the dedication ceremony was attended by Queen Victoria. The

Editorial Comments—*continued*

harbour was intended for military and naval use, but of recent years its chief function has been that of a port of call for trans-atlantic liners. In 1930, the number of passengers embarking and disembarking reached a total of 183,786, but since that date there has been a falling-off, due in the first place to the financial slump of 1931.

Post-War Cargo-handling Methods.

One of the matters very prominently in mind at the present time among port managers and stevedores is the possibility, after the war, of introducing speedier and more effective means of handling cargo than those in vogue up to the present. It is generally felt that despite a number of improvements made in existing appliances, there is room for development, both in method and machines. Very close attention is being given to the subject in port circles and endeavours are being made by the enunciation and discussion of fresh ideas to promote a change for the better, which a good many people believe to be overdue.

Perhaps they would hardly go so far in their condemnation of present day methods as Admiral Vickery, vice-chairman of the United States Maritime Commission, who, a short time back, is reported to have expressed the opinion that stevedores were still handling cargo as they did in the days of sailing ships. He certainly overlooked the introduction of the portable elevator-conveyor, the roller runway and a number of other devices which were not at the disposal of an earlier generation and which have done much to facilitate the transfer of freight from ship to shore and *vice versa*. Yet, while disassociating ourselves from his rather sweeping indictment, we feel there is definite scope for improvement in a number of directions.

The trouble is that owing to the heterogeneous nature of cargo and the confined space in a ship's hold, it is extremely difficult to devise mechanism which will meet the varied conditions under which goods have to be handled. It is true overhead trolley rails have been introduced into holds, elevator belts installed in hatchways and conveyor bands on quays, but they do not always lend themselves to convenient use and, in the case of very heavy packages, are scarcely practicable. That is why the quay crane continues to maintain its present ascendancy for all-round work. The double purchase, or burtoning system has also a wide range of utility.

But even admitting the difficulties of the problem, it should not pass the wit of inventors to devise some means of overcoming them. Now that widespread attention is being given to the matter, useful suggestions may emanate from various quarters and it is interesting to note that at the Port of New York Mr. John McKenzie, Commissioner of Marine and Aviation, has circulated a questionnaire seeking information from over a hundred shipping, warehousing and stevedoring agencies at the port. The result of this enquiry is to be embodied in a report which will be awaited as eagerly on this side of the Atlantic as on the other.

Cargo Handling by Jeeps.

The striking and effective use made of amphibious " jeeps " or " ducks " for the discharge of cargo on to the open beaches of Normandy during the recent invasion operations has naturally raised the question of their adaptability to, and possible service in, peace-time conditions. Indeed, such a course has been strongly advocated by a nautical writer in a recent article to *Navy*, which we have read with considerable interest, although his contentions were not altogether acceptable without important qualification.

The method of procedure in Normandy will be recalled from a comment in our last issue in which, on the authority of a press representative who witnessed the scene, it was stated that army stores and general cargo were unloaded into " myriads of Army Ducks " which came alongside the ships, each taking the load of a couple of slings, subsequently crawling ashore across the coastal sand dunes and so right away to their destination in the neighbouring town. The process proved reasonably expeditious and convenient, so that *prima facie* there is much to recommend its adoption under similar suitable conditions.

The writer of the article in *Navy*, however, goes so far as to envisage the ultimate replacement of such typical existing port installations as quays, docks and cargo handling services generally by fleets of jeeps, which, he maintains, could come alongside shipping in any harbour, roadstead or sheltered water, take in merchandise and proceed shoreward to a ramp provided for the purpose of leaving the water, thence to continue their journeys on land to the very doors of the consignee's premises.

We are unable to accept this picture, attractive though it may be, as a satisfactory fulfilment of all the conditions to be met with; certainly not as regards ports of any importance, where so radical a change of method would necessarily entail drastic alterations in structure and equipment, and be subject to unpredictable weather conditions There are certainly grounds for regarding it a feasible, and even a commendable, proposition in the case of ship-discharge on open beaches, or in imperfectly developed harbours in various parts of the world, where cargo-handling facilities are absent, or are of a rudimentary nature. But even here, the point arises as to the availability of a fleet of jeeps adequate for the purpose. The writer of the article gets over the difficulty by suggesting that each freighter might carry its own jeeps, " which could be hoisted over side as soon as the anchors are down and be quickly loaded and ready to proceed to ultimate destination." We are of opinion that this arrangement would entail corresponding difficulties, which might not be readily amenable to treatment. If carried in any number, jeeps would take up useful cargo space in the ships' holds and as a deck load they might prove inconvenient.

He also suggested that " shippers of goods used to dealing with large amounts " would provide their own fleets of jeeps, " just as to-day they provide their own railway wagons and lighters." To do this would necessitate a correspondingly large number of jeeps. The present capacity of a jeep is about 5 tons and much of its available carrying space is taken up by an engine which has to be powerful and is therefore costly. Compared with a 100 or 120-ton Thames barge, it has a much inferior carrying capacity, and while it must be admitted that there are possibilities of enlargement, these would have to be kept within limits of practicability and cost.

However, the article is suggestive and may possibly lead our readers (if they have not already done so) to a consideration of the merits of the amphibious jeep as a cargo-handling appliance for general adoption.

Port of New York Post-War Plans.

The publication of the 23rd annual report of the Port of New York Authority, recently transmitted to the respective Governors of the States of New York and New Jersey, has enabled the Authority to acquaint the American public with its views on the policy to be adopted for the development of the port under post-war conditions. Emphasis is laid on the necessity of active trade promotion if New York is to maintain its position as a " cross roads " of world trade.

At the present time, the Authority is engaged on a two-year programme of new terminal and transportation facilities. Some of the measures in hand concern aspects of city activity which do not essentially lie within the limits of port affairs, as for instance, traffic arrangements in connection with the Hudson tunnels and bridges. But within the precise domain of port operation, there is an important reference to the expansion of sea-borne trade. " This district," the report states, " taps the nation's largest reservoir of cargo and passengers. A vast transport network permits swift and ready interchange by air, rail, ship and motor truck carriers. Residents of this area have, in the past, constituted the preponderance of American travellers abroad and are likely to be the chief users of the overseas air services in the future." Accordingly it is urged that the major air routes must make their principal terminals in the neighbourhood of New York, and that the region must be provided, not only with adequate air ports, but also with efficient facilities for the terminal handling of air-borne commerce. The Authority believes itself to be the agency best equipped to serve the air transport needs of the port district.

The Port of New York is fortunate in being in a position to make a " flying start " immediately peace is proclaimed. Most ports in this country and on the Continent of Europe have a heavy leeway of demolition and damage to make up.

Port of Genoa. Pre-War Interior of Harbour.

The Port of Genoa

A Review of its History and Development

By F. C. BOWEN.

Early Records

WHATEVER the immediate progress of the war, the port of Genoa is bound to take a more and more important part for both the Allies and the enemy, and another chapter of its long and very interesting history is in the making. The first chapter in the story is wrapped in a great deal of uncertainty; the Genoese claim that their city was founded a thousand years before Rome, but of that there are naturally two opinions. Until recently the Greek occupation was almost entirely legendary, but the discovery of a great Greek cemetery dating from the Fourth Century before Christ authenticated the accepted legend. The remains give excellent evidence that the Greek settlement was solidly founded and probably of very considerable age, having communication with Northern Gaul as well as with the Eastern Mediterranean. It would appear that the foundations of the artificial harbour were laid in their days, the Old Mole on the south east of the original port containing material which supports that. The Romans came in the Third Century before Christ; in the year 209 B.C., the town and port were destroyed by the Carthaginians and soon rebuilt, to attain great importance. At the beginning of the Christian era it exported timber, skins and honey and imported olive oil and the cheaper wines, its own wine being reputed the best in Liguria and there being sufficient wealthy inhabitants in the town to consume the entire output.

Generally speaking, the commercial prosperity of Genoa during the golden age of the commercial republic was well merited although the city's history is sullied with the inevitable cruelty of the Italians in the Middle Ages and neighbours had every reason to hate her. When the Byzantine Empire declined, and its police fleet was withdrawn from the Mediterranean, piracy became so rife that shipping almost ceased and Genoa was one of the first to make a stand, equipping the ships well and paying careful attention to the training of the men.

In early historic days Genoa showed more enterprise than Venice or any other Italian city. Early in the 11th Century it was allied with Pisa in expelling the Saracens from Sardinia, but the two republics fell out over the division of the loot and a series of quarrels started which finally exterminated Pisa as a maritime power. The first action of the Genoese was to exploit the trade of the countries occupied by the Saracens and the north coast of Africa, but they saw the advantage of helping the Crusaders in 1097, for which they received trading concessions which broke parts of the monopoly held by Venice. That was the first occasion when ships built by Genoa were discussed and their high quality admitted; they were rather smaller than the Venetian ships, 75 feet over-all, with three masts lateen-rigged, and although they used oars when necessary, they were essentially sailing vessels and started the Genoese policy which lasted for centuries, leaving Venice the superiority with the pure galley, and greatly increasing Genoese trade. At the same time, a number of fortified trading colonies on the Spanish and Barbary coasts, the Levant, Black Sea and even on the Euphrates were established.

Rivalry with Venice

From the earliest days progress had been checked by internal trouble; the commons and merchants constantly fought against the nobles and both sides drew foreign interests into the quarrel whenever opportunity offered. Venice naturally made the most of that. But the enterprise of the mercantile community was only partly diverted and its ideas were often astounding. In 1291 two Genoese galleys sailed on what was regarded as a mad expedition to the south to find a sea route to India, long before the possibility was considered anywhere else. Nothing further was heard of them and other adventurers were discouraged, otherwise the whole of history would have been changed. At the very beginning of the 14th Century, backed by the Lombard bankers, there was quite an elaborate system of marine insurance. Better government was

Port of Genoa—continued

started in 1339, when the first Doge was appointed for life and although the period of French domination, ended by Andrea Doria in 1528, naturally checked trade it did not altogether suppress it.

All the time the bitter enmity with Venice went on with great cruelty on both sides, doing infinite harm to both ports and giving an opportunity to the Barbary corsairs of which they took full advantage. Only for one period in the 13th Century did the two maritime cities really combine against their common enemy the Emperor, but even then they were suspicious of one another and when combined operations were arranged against the Algerines, the Commander-in-Chief could never be sure that the old bitter hatred would not burst into flame, even in the middle of a battle. Otherwise the ships of the two ports attacked one another at every opportunity, singly or in fleets, and in regular warfare the Venetian galleys, which were the finest in the world and built with the greatest care, which began with the very careful selection of the timber, at the right phase of the moon, by government officers, were generally the more successful.

In due course, it became obvious that the pure galley was quite obsolete for trading purposes. Venice wanted to retain her old advantage as far as possible and in the Middle Ages developed the galley into the galleasse, while the Genoese made a clean break with the old type and developed the carrack, a broad, deep sailing vessel which was also favoured in Flanders and which was capable of making regular sailings to Northern Europe.

Like the other Italian republics, the decline of Genoa began with its prosperity and the luxury of the people. The first serious blow was in the Eastern trade, but that was largely balanced by the profits from mercenary services rendered to Spain, who had proved quite unable to supply the necessary shipping services for her new Empire. But the traditional enterprise of the rulers was declining; Columbus, who was a Genoese himself, failed to get any support from his own countrymen and had to turn to Spain. Marseilles was in bitter rivalry for a large section of Genoese trade, and the advancement of Trieste, although it was not as serious for Genoa as it was for Venice, contributed to the steady decline.

The Ligurian Republic

The old patriarchal system of government completely disappeared under the wave of republicanism at the end of the 18th Century. The Ligurian Republic was established in 1797, Genoa having to capitulate three years later after being blockaded at sea by the British and on land by the Austrian army. After the battle of Marengo it surrendered to the French and was formally annexed to the French Empire in 1805. For the loss of its identity and its overseas trade through the British blockade there was little comfort in Napoleon's appreciation of the qualities of ships built in the port; some of the best additions to the French line of battle came from Genoese yards, which contracted for all types, until Liguria was liberated in 1814.

When Napoleon was finally overthrown, Genoa expected to become the capital of an independent republic, but by one of those secret clauses in a peace treaty which always cause trouble, it was made part of the Kingdom of Sardinia. That disappointment caused a smouldering republican feeling which has never been extinguished, but it did not check the progress of the port and its shipping. It still had to face the keen competition of Marseilles which to a certain extent had the same hinterland, and for a long time was handicapped by the poor facilities, the lack of wharves and warehouses demanding lighterage. A big emigration business to South America started in 1850 and ten years later the King of Sardinia became King of Italy, which greatly increased the entrepôt trade through the free port.

The Galliera Mole at Genoa.

The Modern Port

The modernisation of the port started in 1870, but progress was very slow and the citizens became alarmed at the manner in which they were losing trade to Mediterranean rivals and the fact that they could not take advantage of the opportunities offered by the opening of the St. Gothard Railway. They applied to the Italian Government for help, but the treasury was empty and the situation was critical until the Duke of Galliera made a gift of 20,000,000 lire (£800,000) which was spent on port development, including a new mole which bears his name, six new jetties, twenty miles of railway and stations, a very inconvenient and badly designed Custom House, warehouses and hydraulic cranes. The work took a long time to carry out and was not, of course, completely covered by the Duke's gift. By 1888, the main harbour had a total area of 492 acres, the outer harbour having an entrance 2,293 feet wide and the inner harbour 1,083. There was between 25 and 26 feet

Port of Genoa—continued

of water alongside the 20,000 feet of quay, including ten jetties, and cranes up to ten tons capacity were fairly numerous. The scheme was completed in 1897, by which time the depth of water had been increased in most places to 30 feet and the quayage to 34,000 feet, while the historic shipbuilding industry had been provided with two dry docks and one floater, in addition to modernised facilities for new construction.

The port was also the home of the crack Italian shipping company, the Navigazione Generale Transatlantica which had a high reputation. It was based on the Rubattino Company which had been started at Genoa in 1850 to run services to the East and which had patriotically supplied the ships for Garibaldi's invasion of Sicily in 1860, receiving due reward from the Italian Government when it was formed. In 1877, it came to a working agreement with the Florio Company which ran Mediterranean services and together they got the mail contract for the American service. In 1881 the two companies were completely amalgamated to form the Navigazione Generale Italiana with Government backing, building up a big fleet of the finest merchant ships under the Italian flag, and working up a very large emigrant and considerable saloon business.

Between the turn of the century and the beginning of the First Great War in 1914, Italian trade and shipping went forward rapidly, Genoa taking the lead. By the outbreak of war the total area of the harbour had grown to 530 acres, with water up to 33 feet in depth at most of the quays. The coal trade, which had become of immense importance, was provided with eight electric bridge cranes for discharge and the general trade had a considerable number of hand, steam, electric and hydraulic cranes up to ten tons. Heavier lifts were covered by five 60-ton and one 120-ton floating crane. The construction of the Victor Emmanuel Basin to the west of the Galliera Mole had been started for the benefit of the increasing coal imports. In addition to the N.G.I. the port supplied the Lloyd Sabaudo with passenger services to the United States and South America, and its subsidiary, the Societa Marittima Italiana to the Black Sea, Egypt and Bombay. The Banco di Roma ran coastal services, the Italia Company covered North Africa, Portugal and the Canaries, the La Veloce Company, Central America, the Navigazione Alta Italiana, the U.S. and Gulf ports, Peirce Brothers, both U.S. and South America, and the Lloyd del Pacifico and Angelo Parodi, the growing South American business. Genoa was then head and shoulders above any of its rivals and one of the principal ports in the Mediterranean.

Its commercial prosperity killed the old bitterness which had been started when the naval dockyard was moved to Spezia in 1870, taking with it a considerable population, while Genoa became only a minor naval station. In spite of that, its seamen were famous and supplied nearly 50 per cent. of all the petty officers in the Italian fleet.

Shipbuilding Operations

The Genoese also maintained their reputation as shipbuilders which was well founded in the Middle Ages. In the middle of the 15th Century they were building ships up to 500 tons burthen and in 1530 they had built the famous armoured ship *Santa Anna*, the wonder ship of her day, for the Knights of Malta. Odero, Ansaldo and Bacini were the principal yards before 1914, responsible for building the biggest men-of-war and merchantmen under the Italian flag and able to keep well ahead of rivals in other districts in spite of the political influence which was for them and against them by turns.

Pilferage

In the early days of the last war Genoa was the principal centre of blockade-running into Germany and Austria with the result that, as is usual in similar circumstances, there was an immense amount of money in circulation, corruption was rife and labour became seriously demoralised. The congestion, which was to impair the efficiency of the port until the end of the war and long afterwards, started before Italy entered the struggle and very seriously hampered Allied efforts to make proper use of the port. Between 1918 and 1922, inclusive, the underwriters paid an average of 40,000,000 lire per annum for pilferage at Genoa. Defied by organised thieves, the Italian authorities shut their eyes and did nothing. The underwriters charged extra premiums for goods passing through the port and the shipowners shunned it where possible. When they established themselves, the Fascists did at least contrive to rectify matters, establishing a special port militia which exterminated the gangs without mercy. In 1933 the pilferage claims on underwriters amounted to 48,850 lire only.

The party's methods, brutal as they were and undoubtedly used for private enmity as well as for restoring order, made a huge difference and within a very short time nearly 50 per cent. of Italy's trade passed through the port, the figures of Marseilles being passed in 1924, for the first time for many years. Then the political claims of other centres, and the huge hydro-electric scheme which made so much difference to the coal trade, had their effect.

Once again the old enterprise of the Genoese was shown by another big scheme of port improvements, including a new mole to the eastward of the existing ones, reclamation round Cape del Faro and an enlarged dock system at that end. Improving the facilities of the big passenger liners was an important part of the plan and when the record breakers *Rex* and *Conte di Savoia* were commissioned, and brought to the port a very large number of American tourists, the work was fully justified. The extensions were given a very elaborate system of road connections as well as rail, one of the aims of the whole scheme being to get a large proportion of the Swiss transit trade from Antwerp and Rotterdam. The shipbuilding and repair facilities were also greatly increased.

These port improvements were of great utility when Genoa was used as one of the principal bases for the Abyssinian expedition, and although they were still uncompleted when Italy entered the present war, and Genoa was effectively bombarded by the French fleet just before the collapse of France, it was again one of the enemy's most important supply bases for the campaigns in North Africa. From time to time information was received that port labour in Genoa was demanding that Italy should withdraw from the war and its morale was severely shaken by British bombardments from the sea and air. Largely in order to keep this section quiet, vast new schemes for enlargement were published in the latter part of 1941, but after a few months further reports of unrest circulated. Since the collapse of the Fascist regime, Genoa has been the strongpoint of German defence, as well as the principal centre of their coastal supply services, and their propaganda department has published many accounts of the tremendous strength of its defences. In Allied hands, however, it should prove an infinitely more useful centre.

Projected Extensions at Port of Trelleborg.

Improvements at the Port of Trelleborg in the South of Sweden, are contemplated as soon as circumstances permit. The Swedish State Railways propose to construct new and larger ferry berths, which will involve moving the piers and breakwaters; discussions regarding this are proceeding between the State Railways and the Harbour Board. The moving of the piers will make it possible to provide large oil storage depots, the present ones being comparatively small. The cost of the alterations is estimated at several million kroner.

Port Traffic in Denmark.

A statement recently issued by the Danish Bureau of Statistics shows that 55,500 vessels, of about 6,700,000 tons net arrived at Danish ports last year, compared with 45,800 vessels, of 5,100,000 tons, in 1942. A total of 8,050,000 tons of cargo was discharged and 4,860,000 tons shipped, compared with 6,630,000 and 3,290,000 tons respectively in 1942. Of the inward cargo 57 per cent. came from abroad, while 30 per cent. of the outward cargo was for foreign destinations. Of the cargo brought from abroad, 69 per cent. was carried in Danish ships, compared with 36 per cent. in 1938. There were 8,900 arrivals of vessels employed in the regular services between Danish ports, compared with 7,900 in 1942, the net tonnage being 1,190,000, against 1,010,000. The cargo discharged by these vessels was 502,000, against 529,000 tons, while the cargo shipped totalled 504,000 tons, against 421,000 tons.

The Hydraulic System of Operation as applied to Dock Machinery

A Survey of Modern Developments and Adaptations

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(Continued from page 58)

PUMPS

These may be divided into two general types, ram and centrifugal turbine, and may be driven by any form of power, but, generally, either by steam or electricity. With the turbine type pump, the flow of the water delivered by the pump is uniform, whereas with ram pump this is obviously not so, as the displacement produced by a ram pump varies approximately according to harmonic law, varying between a minimum and maximum. In the exceptional case of a single ram pump, this variation would approximate a sine curve per revolution of the crankshaft, and in the case of a three-throw ram pump, three sine curves displaced by 120 degrees.

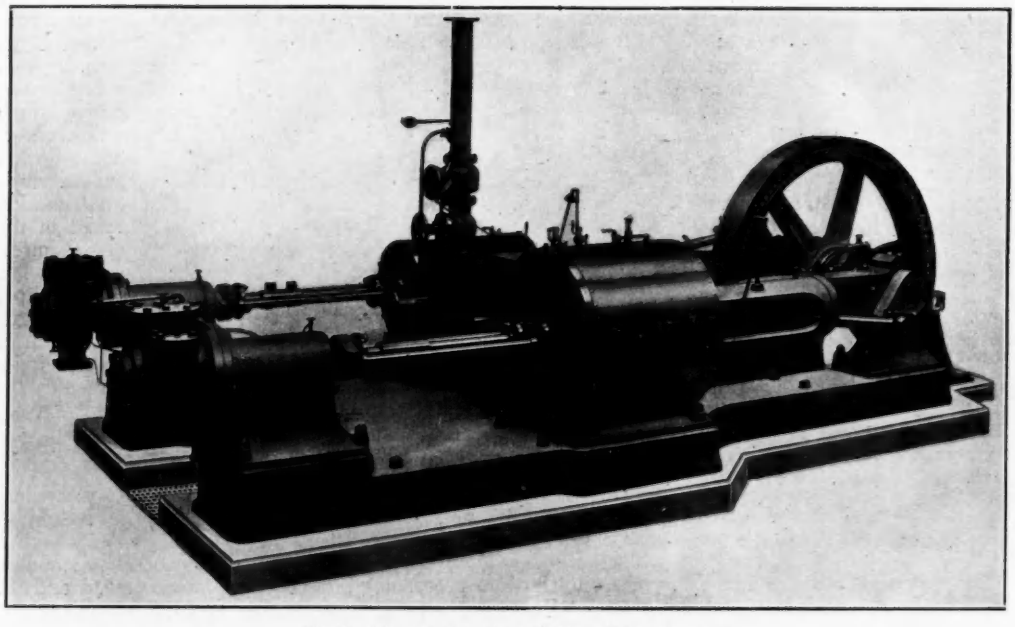


Fig. 5. (The Hydraulic Eng. Co., Ltd., Chester)

In view of above, air vessels are not usually fitted on the delivery side with pumps having a three throw crankshaft, but are utilised on the suction side to reduce the maximum acceleration and velocity in the suction pipe, thus minimising the fluctuations in the suction chamber and liability to water hammer or separation. Air vessels should be mounted as close to the suction chamber as possible, and the connections should not embody sharp bends or tees.

Ram pumps may be single-acting, in which case displacement rams are used, or double-acting, when packed pistons are fitted. An alternative giving the same characteristics as the double-acting pump is one provided with single-acting cylinders and rams in tandem.

Pump cylinders are of cast iron or steel forgings, the rams being of cast iron, stainless steel or cast iron shrouded with gunmetal, neck rings and glands being provided. The rams are fitted with crossheads, working in renewable guides, and the suction and delivery valves are of the mitre spring-loaded type.

The design of ram pump delivery and suction valves has considerable influence upon pump efficiency, and the reasons for this are briefly outlined below.

When the pump ram reaches the end of the suction stroke it is for an instant stationary, after which motion is reversed, and the ram commences the delivery stroke. The suction valve should be closed when this reverse motion commences, otherwise pressure water will be delivered back through the suction valve; actually, however, the valve takes a certain time to close, dependent upon the height of valve life and the strength of the spring assisting closing, the result being that a small quantity of pressure water leaks past the suction valve and is not therefore delivered as pressure water by the pump.

The same effect takes place at the delivery valve, pressure water leaking past the valve, during the time this is closing into the pump cylinder whilst the ram is commencing the suction stroke. The result of this is that the quantity of pressure water actually delivered by the pump is less than that calculated from the ram displacement. This characteristic of ram pumps is referred to as the "valve slip," and for normal designs has a value of from four per cent. to six per cent.

The higher the pressure and the smaller the capacity of the pump, or the greater the ram diameter with respect to the stroke, the greater the valve slip.

In view of the above considerations, suction and delivery valves are of large diameter, and have a relatively small lift, and in some designs smaller valves in multiple are used to further reduce the valve lift.

Flow velocities through suction and delivery valves should not exceed six feet and ten feet per second respectively. Spring-loaded relief valves are fitted in the delivery side of pumps, as general practice, together with non-return valves.

In the case of turbine pumps, a non-return valve must be provided on the delivery side, otherwise, when the pump is not in operation, pressure water from the accumulator will flow through the pump into the suction tank, the turbine pump being valveless. A non-return valve is also essential in order to prevent

The Hydraulic System of Operation as applied to Dock Machinery—continued

the pump running as a turbine under which conditions it may reach a dangerous speed.

Steam Driven Ram Pumps. (Fig. 5)

The driving engine, pump cylinders, circulating pump and air pump are incorporated in one unit, the condenser being mounted directly under the bedplate. The engine may be of the cross-compound, tandem-compound or triple expansion type, and may be horizontal or vertical, the latter requiring less floor space.

The pump cylinders are mounted on the bedplate, either between the cylinder ends and the flywheel or behind the cylinders. In the former case, the pump rams are operated by means of connecting rods from the main crankshaft, and in the latter, by extensions of the piston rods.

The air and circulating pumps are usually mounted vertically and are operated from the main crankshaft by connecting rods.

High pressure steam cylinders may have slide valves or piston valves, and the low pressure, slide valves. Manual control of the steam cut off is also often provided.

Details of Typical Steam Driven Hydraulic Pump

Steam Engine		Water Pump	
Steam pressure...	200 lbs. per sq. in.	Hydraulic pressure	800 lbs. per sq. in.
Superheat ...	150° F.	Capacity	700 g.p.m.
Revs. at full load	48 per minute	No. of pumps per engine	4
Diameter of high-pressure cylinder	24-in.	Type of pump ...	Ram (displacement)
Diameter of low-pressure cylinder	44-in.	Diameter of ram ...	6-in.
I.H.P.	442	Stroke of ram ...	36-in.
Valves, high pressure	Piston	Speed of ram ...	288-ft. per min.
Valves, low pressure	"D" slide	Valves	Spring-loaded mitre
Lbs. of steam per I.H.P.	14.58		

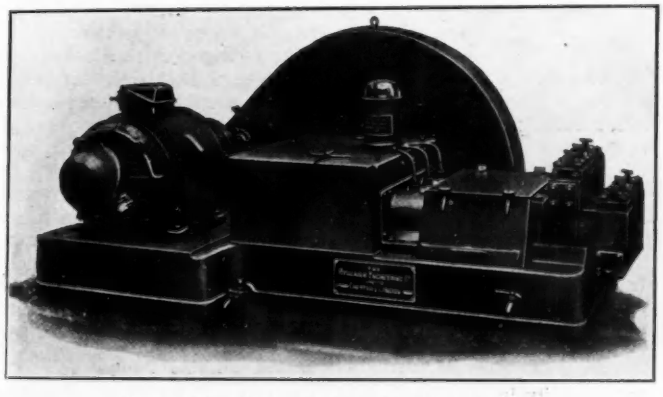


Fig. 6. (The Hydraulic Eng. Co., Ltd., Chester)

Electrically Driven Ram Pumps. (Fig. 6)

Except in the case of small pumps, these are usually designed with three cranks 120 degrees apart, the crank-shaft being driven through oil-immersed double helical gears by a suitable electric motor, connecting rods transmitting motion to crossheads attached to the ram heads. The motion of the crankshaft is such that the thrust upon the crosshead during the delivery stroke is downward, this being taken up by suitable renewable guides, which may be either flat or circular. Speed reduction may be made in one stage, providing that the gear ratio does not exceed ten to one. A flexible coupling should be provided between the motor shaft and gear shaft, and in the case of motors having sleeve bearings, care must be taken that longitudinal armature movement is not transmitted to the gear pinion. Except in the case of very small pumps, the gear pinion should be provided with separate bearings. The above type is invariably arranged as a horizontal pump, and latest practice is to enclose the crankshaft, connecting rods and crossheads in an oil-tight casing, in addition to providing an oil bath and casing for the gearing, all bearing surfaces being lubricated under pressure by means of a mechanically-driven oil pump. Small pumps are sometimes provided with worm gear reduction in place of double helical spur gear.

Examples of Electrically Driven Ram Pumps

	a	*b*	*c*	*d*
Capacity in gallons per minute	22.5	250	250	400
Pressure in lbs. per sq. in.	1600	850	850	750
Crankshaft speed ...	60	60	52	56
Gear ratio	9.5	9.75	9	10.5
Type of gear	Double Helical	Double Helical	Double Helical	Double Helical
Number of rams	3	3	3	3
Ram diameter	2¾-in.	5.8-in.	5½-in.	7-in.
Ram stroke	6-in.	15-in.	18-in.	18-in.
Ram speed	60 f.p.m.	150 f.p.m.	156 f.p.m.	168 f.p m.
Type of valve delivery and suction	Mitre	Mitre	Mitre	Mitre
Type of electric motor ...	Induction	Induction	Direct current shnnt	Induction
Rated horse power ...	35	200	200	290
Motor speed r.p.m. at full load	570	585	468	588
Combined efficiency ...	71¾%	74%	74%	76%
Voltage and system ...	400 volts 3-phase	400 volts 3-phase	Direct current 440 volts	400 volts 3-phase

Turbine Pumps. (Fig. 7)

The multi-stage turbine pump in principle is similar to a centrifugal pump, except that the kinetic energy due to water velocity imparted by each impeller is converted into pressure by means of a diffuser having guide vanes, the necessary head, or pressure, being obtained by mounting a number of impellors upon a common shaft, each impeller having a separate chamber or cell.

The action of the pump is as follows:

From the suction pipe, water enters the first impeller "eye," or centre, via the suction chamber and by centrifugal action is ejected from the periphery at high velocity passing between the guide vanes of the diffuser, where the velocity, or kinetic energy, is changed into pressure, the shape of the vanes being such that this is accomplished with a minimum loss due to friction and eddies. Leaving the diffuser, the water travels at low velocity through a gradually divergent passage to the "eye" of the next impeller, where the same process is repeated.

There may be many such stages as indicated above, the final stage delivering water under pressure to the delivery chamber at the end of the pump, each stage contributing a quota of the total pressure, e.g., a pump having a capacity of 800 G.P.M. running at 1475 R.P.M. delivering water at a pressure of 850 lbs. per square inch will have approximately ten stages.

The construction of the pump is relatively simple, the casing consisting of a number of cast iron, or cast steel, sections, or cells, each having a spigot and faucet and held together by longitudinal bolts between the end covers which form the suction and delivery chambers.

The diffusers are renewable and are fitted into the main casting; guides and diffuser sides are made of bronze, this representating general practice.

Shaft glands are usually fitted with gunmetal neck rings and are water sealed on the suction side of the pump to prevent air leakage, the shaft being provided with renewable sleeves. In addition, provision is made to reduce the gland pressure at the delivery end to a very low figure by leaking back to the suction side. In this manner, any gland trouble is practically eliminated and both stuffing boxes are subjected to approximately suction pressure.

The impellers, which are of the single "eye" type, are usually of bronze, preferably secured to the common shaft by separate keys, bushes fitted to the necks of the impellers, together with a neck ring in each cell, being provided to minimise inter-cell leakage.

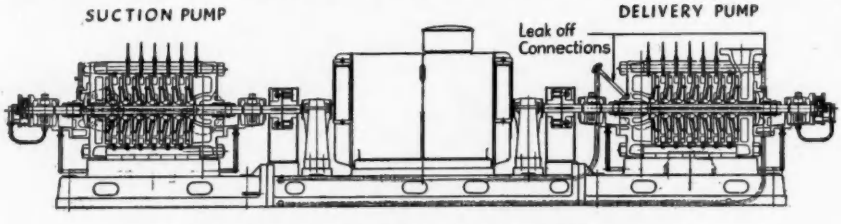
As all the impellers are of the single "eye" type, i.e., having only one axial entry, end thrust is imposed upon the pump shaft due to the following cause:—the difference in pressure upon each side of the impeller due to the difference in area subject to the stage pressure.

The Hydraulic System of Operation as applied to Dock Machinery—continued

This unbalanced thrust is compensated by means of a balancing disc, fitted to the pump shaft and almost in contact with a circular seat fixed to the delivery cover. The space enclosed by the disc and seat is supplied by pressure water from the last stage of the pump through a leakage path, formed between the impeller bush and the central bush in the delivery cover, the clearance being in the order of $\frac{6}{1000}$ of an inch.

The pressure imposed upon the balancing disc by the leakage water is in the opposite direction to the axial thrust, thus giving automatic pressure compensation and automatic balancing, the balance water passing between the disc and the seat being discharged into the suction main or tank.

It is preferable to have this discharge arranged to be visible, as this gives a good indication of the efficiency of the balance, which is being obtained; too much water indicates an increase in the clearance dimension caused by the scouring action of the water, usually due to solids in suspension; too little indicates the clearance is becoming less, due to the deposited solids forming a thin scale upon the delivery chamber and impeller shaft bushes.



SECTION THROUGH TYPICAL SERIES PUMPING SET FOR HYDRAULIC PRESSURE SERVICE

Fig. 7. (Messrs. Mather & Platt, Ltd., Manchester)

The loss of pressure water for balancing purposes amounts to approximately 2 per cent. of the total output in large size pumps.

On account of the fact that the hydraulic system is subject to shock, due to the pressure surges which may cause momentarily metallic contact between the rotating balance disc and the stationary seating, causing excessive wear; a Michell thrust bearing is usually fitted, serving the purpose of a damping type mechanical thrust bearing which prevents this metallic contact. When automatic starting and stopping is adopted, the forces acting upon the balance disc are increased very considerably, and hence for such pumping sets a Michell thrust bearing is even more necessary than for a pumping set operating continuously without an accumulator.

For pressures of 700-800 lbs. per square inch at speeds of approximately 1500 R.P.M., the number of impellers becomes large, and the pump is often divided into two sections, and the driving motor mounted between the two pump units, e.g., a pump delivering 800 G.P.M., at a delivery pressure of 850 lbs. per square inch, may be designed with 13 stages, divided into two units of six and seven stages, an external delivery pipe connecting the sections.

Pumps may be designed to run at speeds of about 3,000 r.p.m. Direct-coupled electrically driven pumps supplied from 50 cycle alternating current circuits running at 2,900 r.p.m. approximately. Direct current motor driven pumps may be designed to run at 3,000 r.p.m., the increase in speed between the motor and pump being obtained by the use of a gear box having double helical gears, provided with forced lubrication. By the use of the turbine pump, hydraulic installations may be designed without accumulators, the pump automatically supplying the demand as this varies. This aspect is dealt with further under pump characteristics.

The characteristics of the turbine pump approximate to that of the centrifugal pump and may be varied within limits by impeller design. Usual designs give a rise in pressure, or head, with closed delivery of from five to ten per cent. and an increase in the quantity delivered with a fall in pressure.

With accumulator-controlled systems, the pump always works on the stable part of its characteristic, therefore, it is possible to use a slightly unstable characteristic provided that the closed valve pressure exceeds the accumulator pressure, as it is obvious if the closed valve pressure is below the accumulator pressure, the pump cannot discharge into the accumulator until that reaches the bottom of its stroke, the demand thus exhausting the accumulator with consequent reduction in pressure.

Such a method of operation is undesirable and may result in violent pressure surges. In order to avoid such a difficulty, it is usual to design the pump with either a strictly stable characteristic or with a semi-stable characteristic. The semi-stable characteristic is a compromise and is occasionally adopted to obtain two per cent. to three per cent. increase in efficiency.

Great improvements have been made recently, in methods of obtaining the stable characteristic without sacrificing efficiency, and it may be assumed in the very near future that pumps having stable characteristics without a loss in efficiency, will be generally available.

The simplest hydraulic installation is one in which the accumulator is dispensed with, hydraulic power being provided by turbine pumps. In such an installation, it is essential that the pressure, g.p.m. characteristic of the pump should be absolutely stable, i.e., the pressure should fall continuously as the rate of flow is increased, and should be the maximum with closed delivery valve or zero rate of flow.

A characteristic of this nature makes it possible to eliminate inherent surging, and hence the pump may be used to deliver direct into the hydraulic main.

As it is possible with such a system for the demand to fall to zero for periods which cannot be pre-determined, there is a possibility that the pumps may be called upon to operate against a completely closed system for long periods.

Under such conditions, the energy imparted to the water inside the pump is transformed from mechanical energy to heat energy with resulting rise in temperature of the water. The rate of rise in temperature may be considerable since the power absorbed at zero rate of flow is approximately 44 per cent. of that at full rate of flow, and the difficulty is increased when using a 3,000 r.p.m. Pumping Set. It is desirable, therefore, to provide means of recirculating from the pump discharge side to the suction storage tank at a rate of flow sufficiently large to permit, by radiation, disposal of the heat generated inside the pump. An automatic leak-off valve under the control of the pump discharge non-return valve may be fitted in this case.

Examples of Electrically Driven Turbine Pumps

Pump capacity in galls. per. min.	250	800	500	400	250
Hydraulic pressure lbs. per sq. in.	750	850	725	850	750
Pump speed r.p.m.	2900	1475	1475	2900	1475
Type of Drive ...	Gear	Direct	Direct	Direct	Direct
Number of stages	8	13	13	9	14
Type of motor ...	shunt	induction†	induction†	induction*	shunt
Motor h.p.... ...	218	700	370	365	195
Motor speed r.pm.	1250/1600	1475	1475	2900	1475
Michell Thrust Bearing	not fitted	fitted	fitted	fitted	not fitted
Combined Efficiency	60%	67.4%	65.9%	65%	64.7%
Method of control	pump runs continuously	accumulator	accumulator	accumulator	pump runs continuously
Voltage and system	500v. D.C.	6600v. 3-phase	400v. 3-phase	6600v. 3-phase	500v. D.C.

*Double wound squirrel cage
†Standard wound rotor

Types of Electric Motors Used for Driving Hydraulic Pumps

Ram Pumps

Direct current motors are usually shunt wound and, in large sizes, provided with interpoles in order to ensure good commutation, particularly during the starting period. Speeds are more or

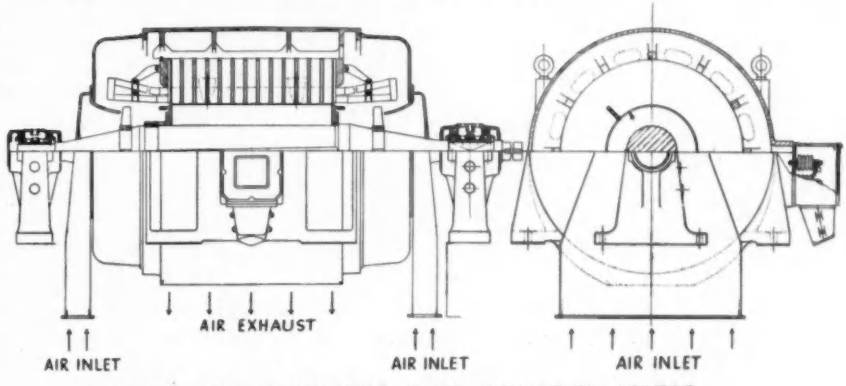
The Hydraulic System of Operation as applied to Dock Machinery—continued

less fixed between the limits of 600 to 800 r.p.m., with single stage reduction gear if the ram speed is to be within 180 feet per minute. For the same reason, alternating current induction motors run at approximately 575 to 580 r.p.m., full load speed (600 r.p.m. synchronous speed) on 50 cycle circuits and may be fitted with wound or squirrel cage rotors. In cases where speed control of pumps is necessary and an alternating current electric supply is available, rotor fed A.C. commutator motors of the Schrage type are used, whereby a maximum speed variation of approximately 10 to 1 is obtainable by altering the position of the movable brushes, maximum speed being obtained when the movable brushes are in line with the fixed brushes, minimum speed occurring when the movable brushes are midway between the fixed brushes. Alternating current auto-synchronous motors may be used where power factor limitations warrant this, but arrangements should be made in order that the motor may run continuously and in cases where accumulator control is adopted, it may be worth while to instal a coupling of the electric or hydraulic type, controlled by the accumulator ascent and descent. Alternating current motors of large output from 400 to 1,000 b.h.p., are often wound for high stator voltages (6,600 to 11,000), the rotor voltages being correspondingly high and in the range of from 1,000 to 2,000 volts.

Turbine Pumps. (Fig. 8)

The provision of suitable electric motors for the purpose of driving large high-speed turbine pumps, running at approximately 3,000 r.p.m., presents certain problems of design.

In the case of direct current motors, due to the difficulty of adequately securing armature windings and obtaining satisfactory commutation with standard designs at speeds above 1,800 r.p.m for machines of 200 b.h.p. and over, direct drive is limited to pumps running at about 1,700 to 1,800 r.p.m., when considering outputs of 200 gallons per minute and over at from 700 to 900 lbs. per square inch hydraulic pressure. Alternating current induction motors are most generally used having a full load speed on 50 cycle circuits of from 1,470 to 1,480 r.p.m. (1,500 r.p.m. synchronous speed) or alternatively a full load speed of 2,900 r.p.m. (3,000 r.p.m. synchronous speed). The lower speed motors may be fitted with wound or squirrel cage motors, whilst those for the high speed have squirrel cage rotors, in view of the difficulty of securing rotor windings against the effects of centrifugal force and shocks occasioned by starting and stopping the motor. In this connection, it is fairly obvious that the design of a wound rotor to run at about 3,000 r.p.m. presents similar difficulties to that of the cylindrical field of a turbo-generator and squirrel cage rotor, referred to above, are of special design, different makers favouring alternative methods of attaining the same result, i.e., reduction in the value of the initial starting current when the motor is switched directly on to the supply system, a standard squirrel cage motor requiring an initial starting current which may approximate ten to twelve times normal full load current against from 3.5 to four times full load current in the case of the special squirrel cage rotor machine.



SQUIRREL CAGE VENTILATED TYPE INDUCTION MOTOR
TO DRIVE CENTRIFUGAL PUMP FOR HYDRAULIC PRESSURE SERVICE
CAPACITY 2,000 H.P 3,000 R.P.M.

Fig. 8. (Messrs. Mather & Platt, Ltd., Manchester)

Methods of Hydraulic Pump Control

Almost all large pumping plants are provided with accumulator control which operates in the following manner:—

The accumulator is installed adjacent to the pumping station, and is connected directly to the delivery main. When the demand for hydraulic water is less than the quantity of water delivered by the pumps, the accumulator rises, the cylinder being filled with water under pressure. Upon the accumulator approaching the upper limit of the ram travel, this movement is utilised to shut down the pumps, the accumulator delivering pressure water to the system because of the downward travel of the loaded ram in the cylinder forcing the water out of same. Upon approaching the lower limit of the ram stroke, this movement is utilised to start up the pumps, which, by means of a series of tappets or other device, may be started up in sequence. Hence, the pumps are automatically started up and shut down in accordance with the demand for hydraulic water .

Exceptions to the above arrangements are relatively small turbine pump installations, in which the pumps may run continuously, no accumulator being provided, this phase of pump control having been dealt with previously.

For the purpose of controlling steam driven pumps, a mechanical connection, usually a chain or wire rope, between the accumulator and the steam throttle valve arranged to close the valve when the accumulator rises to within about three feet of the upper limit of the stroke, and open the throttle valve as the accumulator descends, is provided. A refinement of the above method is the provision of an oil filled cylinder, having a ram or piston which is pressed downwards as the accumulator descends by a weight suspended by a chain attached to the accumulator. The oil contained in the cylinder under the pressure caused by the weight flows through pipes and selector valves to a small cylinder, the ram or piston of which operates the throttle valve of the engine driving the hydraulic pump selected.

Electrically-driven pumps are controlled by a series of tappets fixed at the top and bottom of the accumulator weight. These engage tappet switches which disconnect the control circuit at the top of the stroke and make the connection at the bottom of the stroke, thus stopping and starting the pumps. A selector panel enables any pump to be controlled by any accumulator tappet, thus facilitating pump operation sequence, it being possible for instance, in the case of a station having three pumps, to arrange to run two pumps continuously, the third pump running intermittently in order to deal with peak demands. Generally, this system of control automatically switches in a sufficient number of pumps to deal with the demand.

Further, the greatest advantage of the accumulator capacity is obtained, as, when the accumulator has ascended to the top tappet thereby switching out the pump or pumps, these remain out of action until the accumulator descends to the bottom tappet.

A low water float operated switch is provided at the suction tank supplying water to the pumps which disconnects the control circuit, thus shutting down all pumps should the water in the suction tank fall to a level whereby air may be drawn into the pumps.

The control circuit operates magnetic contactor switches, short circuiting a series resistance in sections in the case of Direct Current motors, and a rotor resistance in the case of Alternating Current induction motors during the starting up period.

Contactor starters are provided with a main contactor, connecting the motor with the electric supply, and usually from four to six contactors which short circuit the series starting resistance in from three to five steps, thus progressively reducing the resistance from a maximum to zero during the starting up period.

The Hydraulic System of Operation as applied to Dock Machinery—continued

In the case of alternating current wound rotor induction motors, the main contactor energises the stator, all the resistance being in the rotor circuit. Acceleration and sequence relays ensure the resistance steps being short circuited in the correct sequence, i.e., 1 to 2, 2 to 3, 3 to 4, 4 to 5 and control the time of the starting period. Overload relays opening the contactors under overload conditions protect the motor from damage due to excessive current.

High tension alternating current (6,600 to 11,000 v) starters may have either oil immersed or air break magnetically operated switches for the stator circuit, rotor resistance and contactors being of usual design.

Where high tension alternating current is utilised for the stator circuits of induction motors, a small transformer is provided for the purpose of supplying current to the control circuits at from 230 to 400 volts. In this case, it is desirable to provide an electrical interlock between the high tension switch and the low tension service.

A special method of control is used for 3-phase commutor motors. In this case, the movement of the accumulator is so arranged to move the brushes as previously described, with the result that if the demand on the hydraulic system causes the accumulator to fall, the motor is speeded up, and as the accumulator rises due to less demand, the motor is slowed down, but remains running during the whole period. Where squirrel cage induction motors are used, all that is necessary is a contactor switch for the purpose of connecting the stator circuit to the electric supply, providing the current demand during the starting period can be borne by the electric supply system.

Where limitations of the value of the current which may be taken from the electric supply system are imposed, a resistance or reactance starter may be used. This comprises one main contactor and one short-circuiting contactor, together with the necessary timing and overload relays; the sequence of operations being:—

(1) The stator is connected to the supply system with the resistance or reactance in series.

(2) The resistance or reactance is short-circuited as the motor gains speed.

In the case of auto-transformer starting, from 8 to 12 contactors may be necessary. The whole object of either method of starting being to prevent the electric supply to the motor being interrupted during the starting period. All electric starters for hydraulic pump control should be of frequent duty rating, as with usual accumulator sizes, the maximum number of starts per hour may approximate 22 in number.

(*To be continued*)

The Institute of Transport

Revised Conditions for the Institute Awards

The Council of the Institute of Transport has issued a circular setting out revised conditions for certain awards, in which the following are included:

Dock and Harbour Authorities' Association Awards.—Presented by the Dock and Harbour Authorities Association. (i) £15 available for award annually for a meritorious paper on a dock, harbour or conservancy subject. (ii) £5 available annually for a paper of merit on a dock, harbour or conservancy subject by a Graduate or Student or for a specially praiseworthy performance at the Graduateship or Associate Membership examination by a Student or Graduate engaged in dock, harbour or conservancy work (as the Council may decide on reviewing papers submitted and performances at the examinations).

Sir Alfred Read Award.—Presented by Sir Alfred Read, Past President. A silver medal and £25 for award annually to a member of the Institute for a paper of merit presented to the Institute on a subject dealing with coastwise shipping in relation to other forms of internal transport. Preference to be given to a paper which has been read at a meeting and has given rise to a good discussion.

Canal Association Award.—Founded in 1923 by the Canal Association. An annual prize of £10 for a paper of merit on a subject relating to inland water transport by a member or non-member of the Institute and presented to the Institute with or without having been read at a meeting. Preference should be given to contributions by writers under thirty years of age. (Note the first award under the new arrangement will be available in 1946).

The Institute Shipping Award.—£15 offered annually by the Institute for the best paper presented to the Institute by a member on a shipping subject.

The Institute 1944 Award.—£15 offered annually by the Institute for the best paper presented to the Institute by a member on a subject not coming within the scope of the other awards.

The Institute Graduate Award.—£15 offered annually by the Institute for the best paper presented to the Institute by a Graduate.

The Institute Student Award.—£10 offered annually by the Institute for the best paper presented to the Institute by a Student.

"Modern Transport" Award.—Founded in 1920 by the Proprietors of "Modern Transport." £5 for award annually either for a paper by a Graduate or Student which has not been awarded any of the other prizes but which is deemed worthy of recognition, or in recognition of a praiseworthy performance at the Graduateship examination which has not qualified for any other prize.

Sir Alfred Read Examination Prize.—Presented by Sir Alfred Read, Past President. £25 for award annually by the Council for the best performance (being of not less than Honours Standard) at the Institute examinations by a Graduate or Student who is engaged in coastwise shipping.

Institute Examination Prizes.—£20 for the most outstanding performance and £10 for the performance next in order of merit at the Associate Membership examination; £10 for the most outstanding performance and £5 for the performance next in order of merit at the Graduateship examination.

In the foregoing list, the following Awards are new:—Institute Shipping Award, Institute 1944 Award, Sir Alfred Read Examination Prize, Institute Examination Prizes.

General Conditions

(a) For the purpose of making awards in any year, papers read or submitted up to April 30th will be considered, papers read or submitted between April 30th and September 30th being regarded as read or submitted between the following October 1st and April 30th. Only papers which are submitted solely to the Institute will be considered for Awards.

(b) The right is reserved to withhold an award in any year if no paper of sufficient merit is presented or, in the case of the examination awards, if no entry reaches a sufficiently high standard. In such event some alternative recognition may be given to two or more candidates who merit it, by dividing the amount of the Award or in such other way as may be approved by the Council.

(c) The "Notes for the Guidance of Authors of Papers" and "The conditions governing the publication of proceedings" as approved by the Council will apply to the preparation and presentation of papers. The author of any paper submitted may be invited to present it for discussion at a meeting of the Institute, if not already so presented.

15, Savoy Street,
London, W.C.2.

June, 1944.

Notes of the Month

Trinity House Mastership.

H. R. H. the Duke of Gloucester has been re-elected Master of Trinity House and Captain Sir Arthur Morrell, Deputy Master.

Southampton Harbour Board.

On grounds of ill-health Alderman F. Brown, one of the City Council's representatives on the Southampton Harbour Board, has retired and his place has been filled by the appointment of Councillor A. H. Powdrill.

Revival of Herring Fishery at Tyne Port.

Efforts are being made to revive and increase the herring and white fish catches by fishing fleets based on North Shields. Following a deputation to Scottish herring fishery ports, six drifters are stated to have applied for permits to fish from the port and more are expected when the more northerly season finishes.

Death of Dry Dock Company Director.

The death has occurred at Newcastle-upon-Tyne of Mr. Charles Atkinson James, managing director of the Mercantile Dry Dock Company, Ltd., Jarrow, from 1934 to 1942. Mr. James was 61. He had been connected with a number of shipbuilding and ship-repairing establishments over a long period of years.

Belfast Harbour Commission.

Sir Ernest Herdman has been re-elected chairman of the Belfast Harbour Commission. He has filled the position since 1926, and has been a Commissioner since 1904. He is now in his 89th year. Mr. W. A. Edmenson, another member of the Board, received the C.B.E. in the recent Birthday Honours.

Tyne Magistrate on Port Pilferage.

Dealing with several cases of theft from dock premises, Mr. T. H. Smith, chairman of the bench, said at Hebburn-on-Tyne, that the amount of pilfering going on was still very serious and for every case which was brought to light there were thousands of other cases which managed to escape detection.

Formation of Scottish Waterway Committee.

A committee has been formed by the Scottish Council on Industry to investigate the possibility of making the river Clyde navigable for barges into the heart of Lanarkshire and the river Cart to Paisley, and to ascertain what advantages or otherwise that action would have in the industrial development of these areas. The committee includes Mr. James Barr, Mr. Liston Carnie, Councillor Hugh T. MacCalman, with Mr. P. W. Thomas (of the Institution of Engineers and Shipbuilders), as secretary.

Inland Waterways Development.

In the House of Commons, recently, Mr. P. J. Noel-Baker, Parliamentary Secretary, Ministry of War Transport, informed Mr. Ellis Smith, M.P. for Stoke, that the Government were closely examining the future organisation and development of the canals and other inland waterways of the country. The Government desired that means should be found for making the maximum economic use of inland waterways and that they should have their proper place in the general system of inland transport. To this end they had taken the opportunity afforded by wartime control of drawing upon the knowledge and experience available in the industry and had consulted representatives of the canal undertakings and canal carriers about technical and other problems which must be considered in shaping future policy. Where necessary they had also consulted and would continue to consult the planning authorities concerned. The Government were at present giving special attention to certain engineering projects for improving the waterways from seaports to the Midlands. The inquiries did not prejudge the Government's decision on transport policy in general and did not imply any commitment of the Government to financial expenditure.

Humber Conservancy Board.

The Humber Conservancy Board are proposing to recondition the pilotage headquarters at Hull and have applied for the necessary licence to do the work.

Proposed Dockisation of River Hull.

The Hull Chamber of Commerce and Shipping have held a meeting at which the proposed dockisation of the river was discussed with representatives of all interested parties. As a result, a small sub-committee was formed to draft a definite policy.

Proposed Harbour Improvements at Bideford.

The Town Council of Bideford, Devon, has approved a recommendation of its General Purposes Committee, that the town clerk should have an informal conference with the divisional superintendent of the Great Western Railway on the subject of improved facilities at the port. The matter has already been discussed with the regional port director.

Aberdeen Port Development.

An important scheme for the improvement of the Harbour of Aberdeen after the war has been under consideration by the Harbour Commissioners. The estimated cost of the first approved instalment of the scheme is £485,000, including the reconstruction of certain quays and a deep water berth. A new dock entrance is also being considered but a decision on this item has not yet been made.

Plans for Post-War Development at Stornoway.

Stornoway Trustees, superiors of the Parish of Stornoway, under the deed of gift of the late Viscount Leverhulme, have commissioned Mr. Robert Hurd, an Edinburgh architect, to discuss with them the lay-out of the burgh of Stornoway. The Stornoway Pier and Harbour Commissioners and the Stornoway Town Council have already made a similar appointment in connection with their post war schemes.

Scottish Harbour Enquiry.

A joint decision has been made by Lord Leathers, Minister of War Transport and the Secretary of State for Scotland to set up a committee to enquire into the desirability and practicability of co-ordinating the administration activities of the various Clyde port and harbour authorities. The ultimate object of the investigation, of which this the first step, is believed to be a comprehensive scheme for the reconstruction and modernisation of Scottish harbours. It is reported that Lord Cooper will be the chairman of the Committee.

Sir Patrick Dollan, a member of the Clyde Navigation Committee, has stated in a press interview that the various authorities would be asked to submit plans for development so that responsible Government Departments could arrange a long-term programme.

" Official action will be taken to prevent overlapping," he said, " and to ensure that each harbour will be equipped with up-to-date cranes, machinery, loading sheds and railways suitable to their special needs. The Government's desire appears to be that competing authorities should be eliminated. On the Clyde, for instance, there are four harbour authorities. On the Forth there are three.

" It is probable that there will be only one responsible authority for each river, similar to the Port of London Authority. There is no denying that there is need for such an inquiry. On West Coast and Highland harbours alone vast sums will have to be spent to bring them into alignment with modern requirements.

" It has always been a weak point in Scotland's industrial structure that although this country can build giant ships such as the Queen Mary and Queen Elizabeth, as well as the largest and finest warships afloat, it cannot provide facilities for the repair and overhaul of these vessels. Too often their initial voyage to the sea is the farewell voyage so far as the Clyde is concerned. A scheme of vision can remedy this point."

Ministry of Town and Country Planning

Control of Interim Development

The draft of a new Order defining and regulating the powers of control over development to be exercised by Local Authorities during the period between the date of coming into force of a resolution to prepare a planning scheme and the coming into operation of that scheme, has been issued by the Stationery Office on behalf of the Minister of Town and Country Planning. Interim development control has hitherto been exercised through an Order made in 1933 under the Town and Country Planning Act, 1932. The necessity for a new Order rises mainly from two causes: first, the war and the changed outlook on planning have materially altered the requirements to be met in the exercise of planning control; and secondly, the Town and Country Planning (Interim Development) Act of 1943 has given Local Authorities wider powers of interim development control, the practical application of which needs to be more precisely defined.

In view of the abnormality of war-time conditions, it is proposed that the new Order shall remain in force for the duration of hostilities only, at the end of which time a further Order will be made.

The draft Order defines the degree of control to be exercised by setting out five categories of development which are ordinarily to be permitted. Of these the two classes affecting ports and inland waterways are set out in an appendix as follows:

2. The carrying out by **dock or harbour undertakers,** on land comprised in their undertaking, of any development required for the purposes of shipping, or in connection with the embarking, loading, discharging or transport of passengers, livestock or goods at a dock or harbour or the movement of traffic by a railway forming part of the undertaking, including the construction, reconstruction, alteration, maintenance and repair of ways, buildings, works and plant, except

(a) the construction of bridges, the erection of any other buildings (not being structures or erections required in connection with the handling of traffic), and the reconstruction or alteration, so as materially to affect the design or external appearance thereof, of bridges or of any such buildings;

(b) the formation or alteration of any means of access to a highway.

3.—(1) The carrying out by **canal or inland navigation undertakers,** on land comprised in their undertaking, of any development required in connection with the movement of traffic by canal or inland navigation, including the construction, reconstruction, alteration, maintenance and repair of ways, buildings, works and plant required for those purposes, except—

(a) the construction of bridges, the erection of any other buildings (not being structures or erections required in connection with the handling of traffic), and the reconstruction or alteration, so as materially to affect the design or external appearance thereof, of bridges or of any such buildings;

(b) the formation or alteration of any means of access to a highway.

(2) The use by any such undertakers of any land for the spreading of dredgings.

The Royal National Life-Boat Institution.

In the course of the annual report of the National Royal Life-Boat Institution presented at the annual meeting on July 13th, it is pointed out that in addition to the 469 lives rescued by lifeboats, 160 were rescued by shore boats and 11 by auxiliary rescue boats, for which the Institution rewarded the rescuers, making a grand total for the year of 640 lives. The 469 lives were rescued in the course of 411 launches, and 249, or more than half, of the launches were to ships and aeroplanes in distress on account of the war. Lifeboats also saved or helped to save from destruction 47 vessels and boats, and helped 74 more in various ways. From its foundation on March 4th, 1824, to the end of 1943, the Institution had given rewards for the rescue, by lifeboats and shore boats, of 72,766 lives.

The late Sir Joseph Broodbank

A distinguished port administrator has passed away in the person of **Sir Joseph Guinness Broodbank,** whose death we regret to record as having taken place on July 14th, at the mature age of 87. His public services were many and varied, but he was pre-eminently associated with the affairs of the Port of London.

Born on the 15th July, 1857, the son of the late Caleb Broodbank of Folkestone, he was privately educated and then spent most of his life in the service of the London Dock Companies, ultimately becoming Secretary to the London and India Docks Company. When the Port of London Authority was created in 1909, he took up the appointment of Chairman of the Dock and Warehouse Committee, continuing to hold it till 1920. He was a member of the Port and Transit Executive Committee from 1915 to 1922. In 1921, he published in two volumes, his *History of the Port of London*, a work of much erudition and universally recognised as a classic treatise on the subject.

His public services in other directions included the chairmanship and treasureship of the Poplar Hospital for Accidents, membership of the Lord Lieutenant's Advisory Committee for Essex (1912-1935) and of the Dock Rates Advisory Committee of the Ministry of Transport (1922-1934). He acted as Technical Adviser to the Committee of Transport of the League of Nations, as British Commercial Adviser to the Central Rhine Committee, and as Chairman of the Food Investigation Board (1928-1934).

He took a great interest in the formation of the Institute of Transport and was one of its early Presidents (1923-4). A Justice of the Peace for Essex, he was knighted in 1917.

Correspondence

To the Editor of "The Dock and Harbour Authority."

Dear Sir, **Electric versus Hydraulic Cranes**

With reference to Mr. Dalziel's letter of the 10th June, the salient points raised are dealt with in my reply of the 2nd June to Mr. West.

I have not suggested that the saving of a few seconds per cycle of operation was a minor point. Under some conditions it may be that the saving of a few seconds is of paramount importance, hence generalisation upon this question is scarcely permissible.

I regret Mr. Dalziel has misunderstood my attitude in this matter, the only object in pursuing the subject being to endeavour to fairly state the characteristics of the hydraulic crane; the question of whether hydraulic or electric cranes should be utilised in a hypothetical installation is quite irrelevant.

Regarding the question of cost, as Mr. Dalziel is no doubt aware my assertion is based on statements of maintenance costs.

Yours faithfully,
C. H. NICHOLSON,
Docks Machinery Engineer.

Alfred Street, Hull.
July 18th, 1944.

National Dock Labour Corporation and South Wales Docks.

Officials of the National Dock Labour Corporation, Ltd., have made a tour of the ports in South Wales for the purpose of seeing how the scheme is working in that area. The tour was commenced at Cardiff, where Lord Ammon, Chairman of the Corporation, accompanied by Mr. S. C. Parkin, the general manager, was met by Mr. Hugh Roberts, the Regional Port Director and Mr. W. J. Thomas, chief docks manager of the Great Western Railway. The visit was subsequently extended to Swansea, Port Talbot, Llanelly and Newport.

In an interview Lord Ammon praised the work being done at Cardiff docks. He said that everything that had been said about the port, its work and efficiency and the fine spirit of its workers from the highest to the lowest, was more than justified. He thought that there was a big future for Cardiff. Referring to the dock labour scheme, he said that he did not think the country dare let the scheme down. A return to the original position of casual employment would mean that the country was declining.

Retaining Walls

An Article for Students and Junior Engineers

By STANLEY C. BAILEY, Assoc.M.Inst.C.E., F.G.S.

RETAINING OR REVETMENT WALLS, though subsidiary in port construction, are generally necessary for road and railway cuttings in the vicinity of towns, docks and harbours, and at the entrances to tunnels, where the widths available for the particular road or railway are so confined that the cost of the additional land required, and the excavation necessary to allow of earth slopes of 1½ or 2 to 1 would be prohibitive. This is particularly the case when a new road or railway passes through an already built-up area. They are also required to form the wing walls of bridges in railway embankments.

These walls differ from wharf walls in several respects, the chief of which is that there is no front water balancing pressure against that of the earth, and they are not usually liable to full hydrostatic pressure at the back or under the wall, for the surface water that seeps down through the filling at the back is generally drained away through numerous pipes and " weep " holes, placed at intervals in the section of the wall, and by pipe drains under the wall, discharging into a channel or pipe in front of the toe. They are not often so high as wharf walls, and do not have to sustain the lateral pull of ships on bollards fixed on them. Should the wall support a footpath and roadway, these are usually concreted and covered with asphalt, and no surface water can accumulate behind the wall, unless it comes from higher and porous ground at the back of the wall and road.

In the case of railways there will probably be a considerable amount of percolation, whether the railway is supported by the wall, or is in a cutting the sides of which are protected by walls.

Like quay walls, retaining walls are sometimes subject to surcharges on the ground at the back, due to the weight of buildings, etc., and the heavy rolling loads on roads and railways supported by the walls, and also to severe vibration.

Effect of Low Temperatures

If no drainage for surface water percolating to the back of the wall be provided, or should the drain pipes become clogged with earth and clay, which is usual in old walls, then the wall will be subject to a certain amount of hydrostatic pressure at the back, and probably also underneath, and to ice pressure in the winter should the water freeze and thus increase in volume, causing the filling at the back to expand in all directions and push the wall over.

This is a common cause of wall failures in Canada and other countries where severe cold occurs during the winter, also when the thaw sets in, the filling at the back of the wall is so disintegrated that the water saturates it to a greater extent, and reduces its natural angles of repose and rupture, thus increasing the pressure on the wall, which may be greater than that of water pressure alone.

The weight of ice is about 57.2 lbs. per cub. ft., while that of fresh water is 62.4 lbs., the increase in volume of frozen water being one-twelfth, which in a closed vessel will produce considerable pressure, amounting to so much as 13 tons per sq. in. or 1,872 tons per sq. ft.

As this pressure is exerted in all directions, that in frozen ground causes it to swell laterally and vertically, so that only a proportion of the pressure will come on a retaining wall; what this would amount to is problematical, but it will be considerable, in fact sufficient to overturn most walls should the whole of the backing be frozen, but as a rule the maximum freezing depth does not exceed 6-ft. Cuttings in moist Boulder and London clays will stand almost vertical on the face, until the clays dry, when they contract and crack on the surface in all directions; rains then percolate through them and should the water freeze, the whole mass becomes unstable falling away to a flat slope of about 6 to 1.

Most soils in cuttings will stand at a natural slope or angle of repose of 1½ to 1 (33°-41′) in all weathers, and in embankments at 2 to 1 (26°-34′), especially if they are protected by grass, but London clay, Gault clay, Blue Lias laminated clays, Kimmeridge and Boulder clays are very treacherous and liable to slide when exposed to rains and frosts, and the angles of repose may be reduced to 3 to 1 (18°-26′) or even to 6 to 1 (about 10°); consequently it is necessary to drain these materials by cutting Y shaped trenches down the slopes, and filling them with rubble stone leading to a trench or pipe drain at the bottom, or it may be necessary to excavate pits in portions of the slope and fill them with blocks of chalk and stone rubble.

Stratified Sites

The ground on which retaining walls are constructed will probably consist of various more or less stratified formations, and the character of the strata should be taken into account when a suitable wall is being designed.

For instance, as in Fig. 1 showing a railway cutting; should the strata consist of alternate layers of sandstone or limestone rocks, interstratified with clays, sands and gravels, dipping at a steep angle towards wall " A," and so away from wall " B," the strata on side " A " is liable to slide towards the wall, when loosened by heavy rains or after frosts, and a thicker wall will be necessary than would otherwise be required, especially as the surface water will flow towards the wall; but on side " B " as the strata dips away from the wall, the water will also flow away from it, so that a wall on that side could be omitted, unless it is required to support a footpath and roadway, when the pressure against the wall will only be that due to a small amount of backing and filling. Should this kind of strata be more or less horizontal, then retaining walls will not be required, as the strata will safely stand at a steep slope.

If drain pipes through the body of the wall be omitted, then 2″ or 3″ diameter open jointed or agricultural pipes will require to be laid vertically in the rubble backing in the shape of a Y at intervals of about 10-ft. these are connected to pipes under the wall from the back to the front where they should drain to spigot and socket-jointed pipes under the toe, which may be connected to a road sewer if required.

Wall Failures

There are four ways in which a wall may fail, viz.: (1) by cracking vertically in portions of the length and sliding bodily forward; this is not an uncommon cause of failure, (2) by overturning forwards and pivoting on the toe, as illustrated by Fig. 2; this is liable to occur when walls are surcharged by earth or loads, (3) by overturning backwards and pivoting at the heel as shown in Fig. 3; this usually takes place when the filling is saturated with water at the base and subsides, forcing the soil under the wall to flow outwards and upwards, (4) and by cracking horizontally in the body, the upper portion of the wall overturning outwards; this usually occurs in the cases of old brick and rubble masonry walls set in lime mortar which has little tensile strength.

The coefficient of friction for a wall sliding on wet clay is about 0.33 and on dry material it is 0.58 to 0.62 of the weight of the wall; so to counteract the tendency of the wall to slide forwards, the base is given a slope down from the toe to the back, or the foundation may be stepped down towards the back. Another method is to carry the concrete toe of the wall down in a trench about 2-ft. wide and 3-ft. deep, or either short timber or concrete sheet piles may be driven down in front of the toe.

Dwarf walls at the toes of railway and road cuttings if supporting slopes of earth or clays are very liable to slide forward when

Retaining Walls—continued

the ground is waterlogged, so that the footings of these walls should be more deeply founded and drainage holes provided in them.

In Quebec, which is sometimes referred to as the "City of Retaining Walls," several gravity walls have failed after having stood for periods varying from 10 to 30 and even 50 years. These had base widths of one-third, one-fifth and one-seventh of their height, and the failures were found to be due to the cumulative effects of ice pressure and to water percolating through the filling, and collecting at the bases of the walls; not being able to escape readily, the soil became saturated.

Base-Height Ratio.

It is not safe to assume a certain width of base in proportion to the height for gravity walls, without considering the nature of the soil to be revetted and its natural angle of repose, but as some assumption must be made in preliminary calculations, if the base is made $\frac{1}{3}$ of the height, when the earth has an angle of repose of $1\frac{1}{2}$ to 1 (33°-41'), there will be some tension at the back of the wall, which in concrete ones would not be serious, but if made 0.45 of the height, there will be little or no tension, if the earth at the back is not surcharged either by weights, or by a surface slope towards the wall.

In the cases of earth or plastic clays saturated with water, and to resist the pressure due to freezing water, the base of the wall may require to be half the height, this is especially necessary with brick-built walls, because of their lighter weight.

It is better to increase the thickness of the wall at the back by a series of steps from 6 to 12-in. wide, for then the weight of the rubble backing rests on the steps, and assists the resistance of the wall, so that the mean C.G of the wall and backing can be taken in the calculations.

Should the wall have a slope at the back in lieu of steps, the triangle of backing A, B, D, shown in Fig. 4, although it rests on the wall, will actually act as a wedge of pressure forcing it outwards, its weight should be added to that of the wall, and the mean C, G found, the pressure on the wall will be the horizontal component of the whole weight of the backing and filling, so that this type of wall will require to be thicker and heavier than one with a stepped back.

Foundation Depth

As regards the depth of the foundation below the surface of the ground, this will depend upon the character of the subsoil and the pressure on the foundation. Should it consist of hard and compact gravel and sand, a depth of 2-ft. will suffice, and 3-ft. in earth and clays, to escape the effects of heavy rains and frosts, but in countries where the rainfall is high, or where winter frosts occur, the foundations may require to be at least 4-ft. deep. In soft soils and in those of a peaty nature, piling under the wall will be necessary, as these soils are very liable to give way under heavy loads. The piles should be spaced apart each way according to the loads they will be required to carry, and the heads of the piles should project about 1-ft. into the concrete at the base of the wall. A timber platform should not be fixed to the tops of the piles on which to build the wall, as has been done formerly, because the wall will be liable to slide forwards on it, and the platform will decay in time.

The maximum pressure under the toe of the wall on firm ground should not exceed 2 tons per sq. ft. and in hard gravel or clay, 3 tons per sq. ft. for the foundation depths given, but may be more for greater depths. Should the foundation be on rock, a depth of 1-ft. will be sufficient, and the maximum load may be so much as 8 to 12 tons per sq. ft.

When retaining walls face the south, there will be considerable heat on them from the sun during the summer, and in concrete walls, vertical expansion joints will require to be provided at intervals of from 30 to 50-ft., otherwise unsightly cracks will occur in the winter due to contraction. The average coefficient of expansion of concrete per degree Fahrenheit rise of temperature per unit of length is 0.00000545; that of stone masonry is 0,00000417, and of brickwork about 0.00000375, while that of steel is 0,00000689.

Therefore, in the case of a concrete wall, for a rise of temperature of from 10° F. in winter to 120° F. in summer, a difference of 110° F. the expansion in a 30-ft. length of wall will amount to $30 \times 12 \times 0.00000545 \times 110 = 0.21$-in., while in a 50-ft. length it will be 0.36-in.

The expansion joint can be made by a vertical rib or tongue about 12-in. wide by 6-in. in the section of the wall fitting into a groove on the next section, leaving a space of $\frac{3}{8}$-in. between, which is filled with bitumen, or with thick tarred layers of felt similar to that used for damp-proof courses in walls, the outside joint being filled in with 1 to 1 lime mortar. In masonry and brick walls, expansion joints are not so necessary, as expansion and contraction takes place at the numerous joints, and hair cracks occur that are scarcely noticeable; but copings of stone and blue bricks will require expansion joints, for unless these are provided, they will in hot weather rise off their beds, and be liable to be blown down in a gale. Should the wall be constructed during the winter, the maximum expansion space must be allowed, and the minimum in summer.

Calculations for Gravity Walls

There are various methods employed in the calculations for the strength and stability of gravity type retaining walls, this is due to the uncertain nature of the earth pressures, as the angles of repose, rupture, and the weight per cub. ft. vary so much for different soils when wet and dry; so before a wall is designed for a particular situation it is advisable to make some experiments to obtain reliable information on the nature of the soil.

In most soils the angle of rupture, that is, the angle at which the material will break away should the support of the wall be suddenly removed, is about half the angle between the vertical at the back of the wall, and the angle of repose or natural slope at which the material will stand in all weathers. Experiments have shown that the actual angle is slightly less than half, and that the plane of rupture is a slightly concave curve.

The horizontal component of the weight of the wedge of earth between the vertical at the back of the wall and the plane of rupture is taken as the maximum pressure the wall will be required to withstand, as the angle of repose is not reached for some considerable time of exposure to frosts and rains, therefore when the wall is built it will not be so exposed, and will not exert any pressure on it, unless it becomes saturated with water, in which case the angle of repose is reduced, and a greater pressure is brought to bear.

The pressure against a wall will also be affected by the character of the filling at the back, for instance many stratified soils such as shales, indurated gravels and sands will stand at slopes of from 65 to 75 degrees to the horizontal, so that the wall will only be required to sustain the pressure due to the filling, provided there is no accumulation of water.

Fig. 4 illustrates a method of calculating the pressure on a wall that is surcharged with earth, in this case the back of the wall has a slope and the backing will have the effect of a wedge. The weight (V) of the triangle of backing A, B, D should be added to the weight (W) of the wall, and the mean C,G found; its distance (b) from the C,G of the wall alone will be $= \frac{V.A.}{W + V}$, where (a) is the distance of the C,G of V from the C,G of the wall.

The natural slope of the earth filling is assumed to be 30 degrees from the horizontal, the angle between that and the vertical at the back of the wall is bisected, this will give the approximate plane of rupture, which if the soil is waterlogged will take the form of a concave curve.

The C,G of the triangle of backing and filling A, B. C at G, through which the whole weight (Q) acts should be found, and the horizontal components (P) of this will be to the pressure on the wall, acting at a point about $\frac{1}{3}$ the height of the wall.

The moment of the wall and backing will be $= (W + V)y$ and the moment of the earth pressure about the toe will be $= Px$.

If the resultant thrust (R) acts at $\frac{1}{3}$ of the width of the base from the toe, there will be no uplift at the back of the wall, but the nearer it is to the toe, the greater will be the tendency to rise

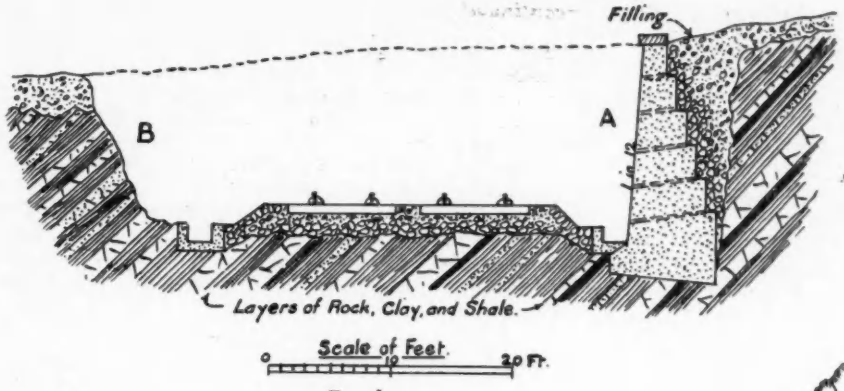


Fig. 1.

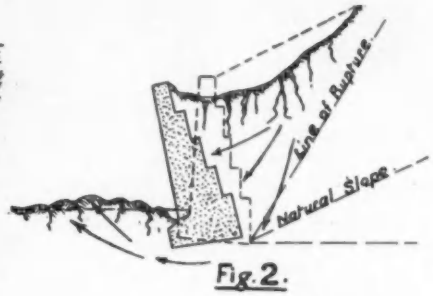


Fig. 2.

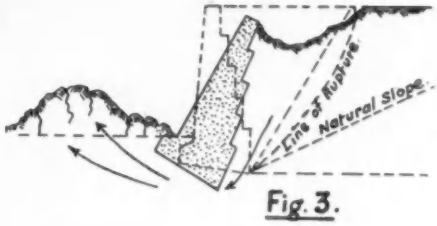


Fig. 3.

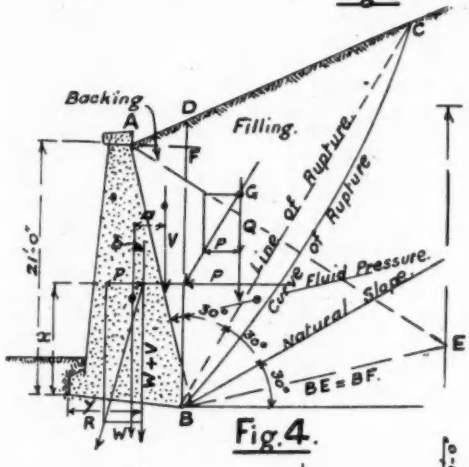


Fig. 4.

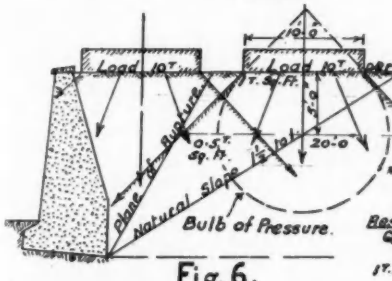


Fig. 6.

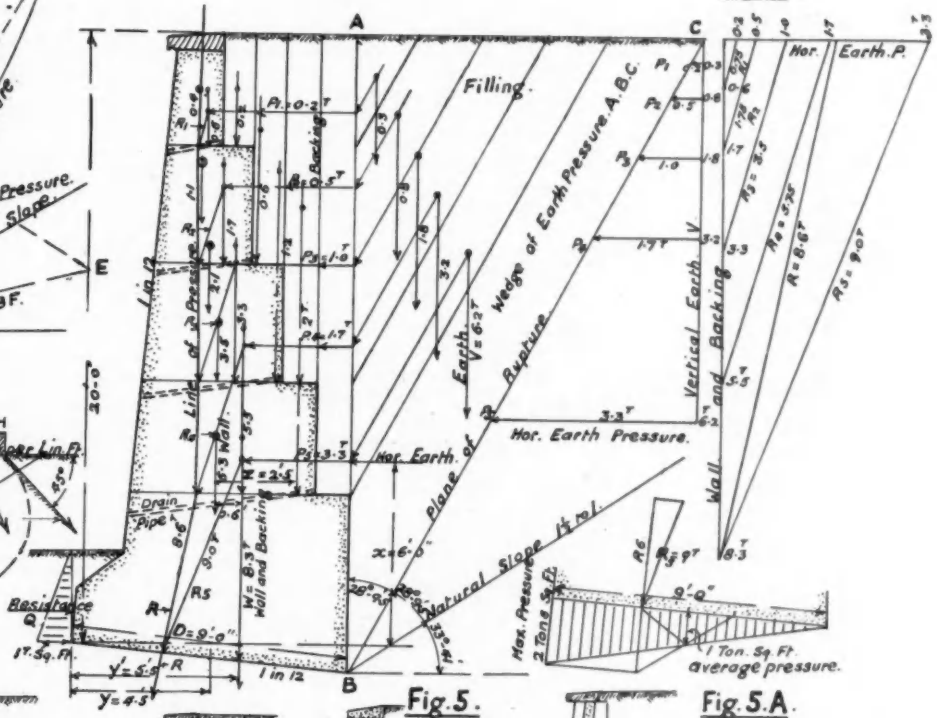
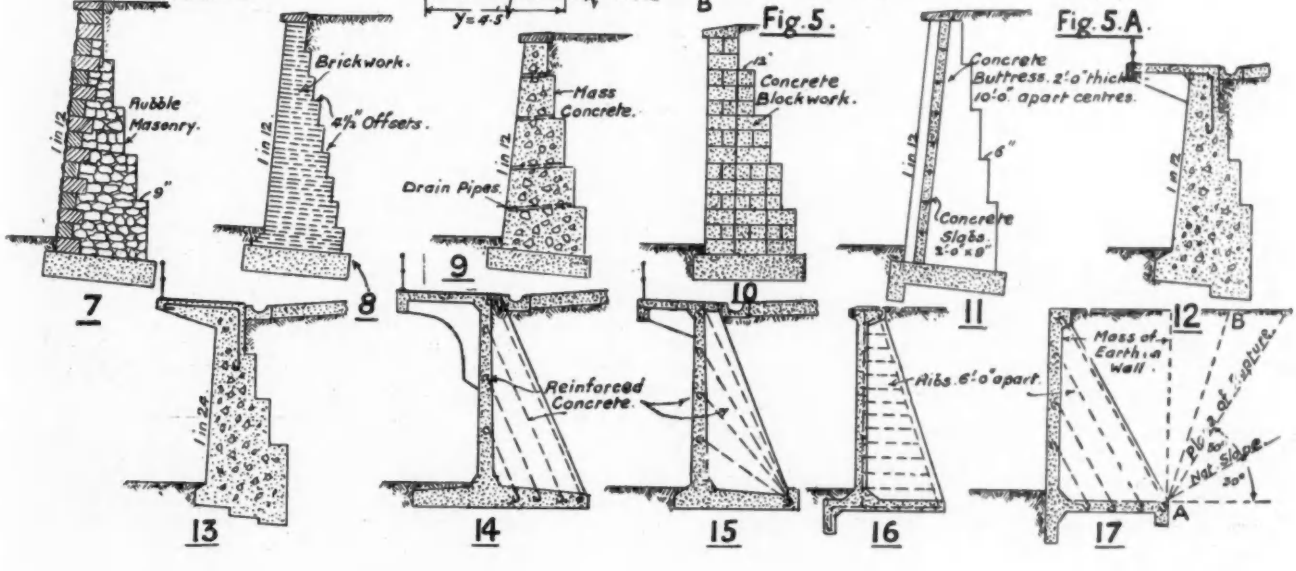


Fig. 5.

Fig. 5.A.



Retaining Walls—continued

at the back. The wall should have a factor of safety of at least 2 against overturning to be quite stable.

Calculations may also be made for the wall on the assumption that it is sustaining a fluid pressure equivalent to that of the earth pressure, as shown by the triangle A, B, E, the volume of which per lin. ft. is 228 cub. ft. for the wall 21-ft. high, and as the vertical weight of the earth (Q) is 15 tons per lin. ft. and the horizontal pressure (P) is 8.5 tons or 19,040 lbs. the equivalent fluid pressure acting at $\frac{1}{3}$ of the height of the wall will be

$$= \frac{19040}{228} = 83.4 \text{ lbs. per cub. ft.}$$

Water pressure alone at 62.5 lbs. per cub. ft. would amount to 6.3 tons per lin. ft., so that a wall surcharged with earth may have to sustain a greater pressure than that from water alone.

In Fig. 5, the graphic calculations are shown for a mass concrete wall 20-ft. high with a stepped back which supports the rubble stone backing from which there is little lateral pressure. The weight of this is added to that of the wall thus greatly assisting the stability of the latter, the total weight acting through the mean C,G of the wall and backing in each section. The natural slope of the earth has been taken at $1\frac{1}{2}$ to 1, the weight of the concrete is 140 lbs. cub. ft. (16 cub. ft. per ton) that of the rubble backing 112 lbs. cub. ft. (20 cub. ft. per ton) and of the earth 118 lbs. per cub. ft. (19 cub. ft. per ton).

The weight of the wall is 6.3 tons per lin. ft. and of the backing 2.0, a total of 8.3 tons, the vertical earth weight is 6.2 tons and the horizontal pressure 3.3 tons, due in this case only to the triangle of earth A, B, C, the small amount due to the backing being neglected.

The mean C, G of the whole wall and backing from the C, G of the wall $= \frac{2 \times 2.5'}{6.3 + 2} = 0.6\text{-ft.}$

The resultant maximum pressure R5 at the base of the wall = 9.0 tons giving as shown in Fig. 5A, a pressure of 2 tons per sq. ft at the toe and no tension at the back. It is usual to take the normal component R6 to the base of the wall in lieu of R5, to arrive at the pressures, but the difference is so small that it may be neglected.

Bouvier's formula for intensity of pressure: $P = \frac{R}{A}\left(1 + \frac{6V}{x}\right)$ in which R = resultant pressure, A = unit area of base, x = width of base and V = distance of R from the centre of the base, tension at the back being neglected.

Another formula which gives the maximum compression and tension in tons per sq. ft. at base $= \frac{Px}{\frac{I}{y}} + N$ in which P = the lateral pressure in tons per lin. ft., N = average pressure on base due to the weight (W), x = height of P above the toe in ft. y = $\frac{1}{2}$ width of base, and $I = \frac{BD^3}{12}$ in foot units, B = 1-ft. length, and D = width of base in feet.

As regards the factor of safety against overturning at the toe, the moment of the wall and backing is 8.3 ton x 5.5-ft. = 45.65-ft. tons, and the moment of P = 3.3 tons x 6-ft. = 19.8, a factor of safety of 2.3.

The force required to slide the wall on dry ground will be 8.3 tons x 0.58 = 4.81 tons, and the actual pressure is 3.3 tons; but on wet slippery soil the force will be 8.3 x 0.33 = 2.74 tons, so the wall will be liable to slide.

If 1 ton per sq. ft. is allowed as the passive resistance of the earth at the toe, the triangle of resistance will be $\frac{3' \times 1'}{2} \times 1' =$ 1.5 tons per lin. ft. and to push the wall up a 1 in 12 slope will require $\frac{8.3}{12} = 0.69$ tons, the resistance to sliding is 2.74 tons, and the passive resistance of the earth = 1.5 tons, a total of 4.93 tons; therefore the wall will be safe against sliding.

In Fig. 6, the effects of surcharges on the ground at the back of the wall due to the weights of buildings, or road and railway traffic are shown, the compression on the ground due to the loads being limited to a pyramid of pressure having slopes of 1 to 1, or to a bulb of pressure under the load; so that when the load lies between the back of the wall and the plane of rupture, it should be added to the earth pressure, but should it fall beyond the plane of rupture, it may in most cases be ignored in the calculations, unless the soil is saturated with water, as it will then sink under the load and be pressed laterally.

Weights of Material

The following are the weights in lbs. per cub. ft. of some materials that may be used as backing or filling behind retaining walls, when the materials are dry and damp respectively, viz.: chalk, 102 to 128; shale, 96 to 100; gravel, 96 to 110; broken stone, 87 to 106; earth, 80 to 105; London clay, 122 to 141; bricks, stones and earth, 66 to 70; stone, rubble and earth, 106 to 126.

Retaining walls to road and railway embankments are liable to be required to sustain additional pressure due to heavy traffic, causing compression of the soil, and probable lateral movement against the walls. Steam road rollers and traction engines will give a distributed load of 0.33 to 0.27 tons per sq. ft. and motor lorries 0.25 ton per sq. ft. of area covered by the wheel bases; the maximum loads on railways which are distributed by the sleepers range from 0.55 to 6.68 ton per sq. ft. of area covered by the gauge and length of train.

At least 50% should be added to these loads to provide for the effects of vibration on the ground. The term " filling " in the diagrams or text does not imply that the soil is to be excavated to the line of rupture before the construction of the wall, because in most cases, the slope of the soil will be left as steep as is considered safe until the wall is built to reduce the actual filling to a minimum. This also applies to cuttings for roads and railways in soft soils, the sides of which are to be protected by walls, the excavation of power driven " navvies," or excavating machinery being reduced on the slopes so much as possible.

(To be continued)

Obituary

Following recent advices, we have to record the passing in the early months of the year of two transatlantic personalities, well-known in port circles on the Eastern seaboard of North America.

Colonel E. C. Phinney, a resident of Halifax, Nova Scotia, where he practiced in the legal profession, was chairman from 1930 to 1933 of the Halifax Harbour Commission, and during that period he did a great deal to promote the interests of the port. He made a tour of Canada to secure business and a Canadian Shipping Journal records that " it was during Col. Phinney's time that Halifax found its place in the sun as a great port. Thousands of bushels of grain, that had never before been routed via Halifax, now went to Halifax elevator, and many American ships out of New York and Boston made Halifax a port of call, picking up a cargo of grain for ballast as well as passengers."

Dr. Roy S. MacElwee had established a high reputation as a writer on port subjects, and his books on " Port Development " and " Port and Terminal Facilities " enjoyed a world-wide circulation. He had travelled widely and spent some time at the port of Hamburg, where he studied methods of port operation. He was Commissioner of Port Development at Charleston, South Carolina, and a Vice-President of the American Society of Terminal Engineers. Among foreign orders which he held was that of Polonia Restituta of Poland.

Errata.—The following corrections should be made in the article by Mr. Donald Becker on " Movable Bridges across Port Waterways," published in the September, 1943 issue: Page 137, line 8, for hard clay read rock; Page 138, line 4, for 16 lbs. per sq. in., read 16 lbs. per sq. ft.

The Construction of Jetties in Exposed Roadsteads

With Particular Reference to the Reinforced Concrete Structure provided at Tolaga Bay, New Zealand*

By GORDON DOUGLAS WHITE-PARSONS, Assoc.M.Inst.C.E.

Introduction.

NEW ZEALAND, with its long coastline and rugged interior, has, from the earliest days of its settlement, been largely dependent on coastal shipping for its local transport. In the North Island road-making materials are sadly lacking, and many districts would be entirely isolated at certain times if it were not for access from the sea. In spite of the excellent natural harbours at Auckland and Wellington, nature has not endowed the coast between with other valuable natural ports or adequate shelter. Ships seeking some protection from the sudden storms that sweep the coast are obliged to creep in under a headland or into one of the river mouths.

For many years the produce from the fertile east coast of the North Island, in which the erroneously named Poverty Bay district lies, was lightered from beaches or from small jetties to the coastal steamers as they lay out in the roadstead, though this operation could be conducted only in very calm weather.

Storms caused many delays, especially when such lengthy operations as the loading of livestock—for which the district is famous—were in progress.

As the various districts prospered, artificial harbours became more and more necessary in order to reduce the delays, and those rivers which for a long time had served a useful purpose were becoming increasingly silted up owing to the denuding of the forest lands of the back country.

Various projects were started and some useful artificial harbours were constructed, such as those at Napier and at Tokamaru Bay. In attempting to solve the problems of the river ports by coping with the difficulties caused by the depositing silt, various experiments were made. With the limited financial resources of the country good harbours proved very difficult to construct in this way and some large schemes had to be drastically modified. However, as some of the larger schemes were progressing the less favoured districts were considering what could be done to facilitate the trade from their productive areas.

The Uawa district, between Gisborne and Tokamaru, noted for its excellent sheep country and dairying industry, continued to lighter its trade to and from the coastal ships from a small wharf inside the mouth of the Uawa river which, at high tide, allowed the passage of motor-driven lighters drawing about five feet of water. The handling of a cargo necessitating more than one trip of the lighters might delay the ship between tides; and owing to increase in silt trouble at the river bar, and the consequent shipping delays, it was decided to investigate the possibilities of providing better shipping facilities. A Harbour Board was therefore formed to consider what could be done.

Of the various possible schemes, the first to be considered was improvement of the existing facilities by deepening the river channel and using a larger type of lighter. Another alternative was to deepen the channel still further, to permit the coastal vessels to come into the river. Although the first cost of such schemes might not seem excessive, maintenance of the navigable channel up the river and for some considerable distance out into the bay could be done only at heavy cost and would impose a perpetual annual liability upon the district. The experiences of other harbour authorities along the coast had been such that, for the money available, any scheme for tampering with the river could not be very favourably considered.

Similarly, the construction of protective breakwaters could not be considered as an easy solution owing to the impossibility of obtaining locally suitable stone for the construction of rubble breakwaters, and the enormous cost of construction in concrete alone with shingle brought, say, from Napier which is 120 miles distant by sea. Therefore the Consulting Engineer, the late Mr. C. J. R. Williams, Engineer to the Lyttelton Harbour Board, considered that the best plan would be to provide a wharf running out into the bay far enough to reach a depth of water permitting its use by coastal ships at all states of the tide; and this course was eventually decided upon. The designs were prepared in detail by Mr. Williams, assisted by the Author, who later acted as Resident Engineer to the Tolaga Bay Harbour Board.

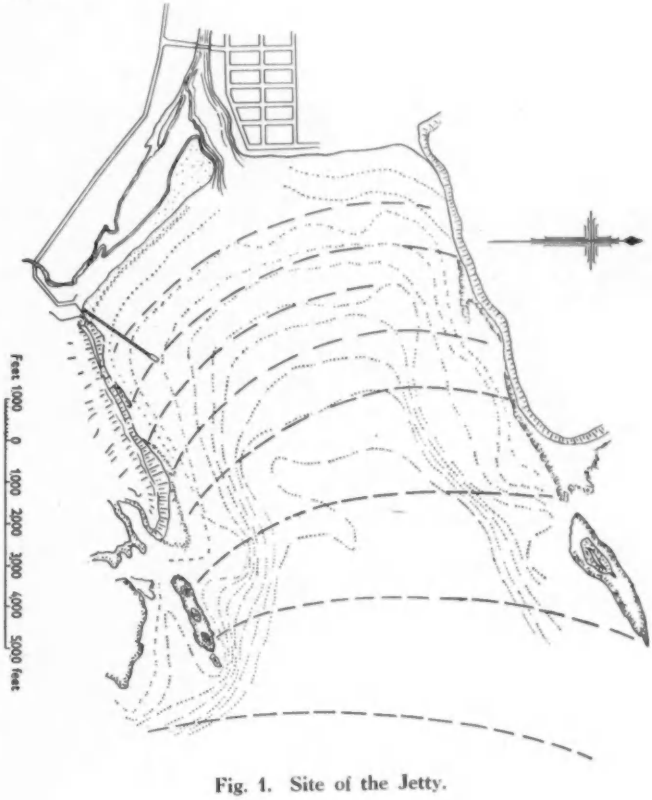


Fig. 1. Site of the Jetty.

Siting the Jetty.

Tolaga Bay is approximately 1½ mile across, and its opening to the sea faces north-east (Fig. 1); therefore it is open to the Pacific storms from the east. These storms rise suddenly and heavy seas of long wave-length and with a height of, say, 12 feet from trough to crest, can frequently be measured. As the wind and the sea fall, the waters of the bay soon become calm again. The tidal range between low and high water of spring tides is 6 feet. Cliffs about 200 feet in height project on the north side for 1½ mile seaward, and on the south side for 1 mile seaward. Continuations of these two promontories exist in the form of islands and reefs farther out.

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Construction of Jetties in Exposed Roadsteads—continued

Fortunately the south headland provides excellent shelter from the southerly storms, which are the cause of delays to shipping at all the other ports along the east coast. When the wind veers more towards the south-east, as usually happens, the effect of the seas is felt in the south-west corner of the bay. When waves run into the bay from the south-east the contours of the seabottom and "drag" from the south shore tend to lead the waves into the south-west corner; but as their height is reduced considerably by this turning action, the effect is not serious.

The south-west corner, with its good shelter and anchorage, was that usually chosen by ships when sheltering, or when working lighters. The fact that the run of the waves into the south-west corner of the bay maintained an almost constant direction, independent of the direction of the weather outside, is noteworthy.

The comfort with which a vessel can lie alongside any structure depends largely upon the possibility of holding her head-on to any wave action. This applies even in harbours protected by breakwaters, where the slow periodic movement of the enclosed volume of water may be hardly perceptible, yet very troublesome, if there is any component which strikes broadside on to a ship at a jetty. The importance of this was fully demonstrated

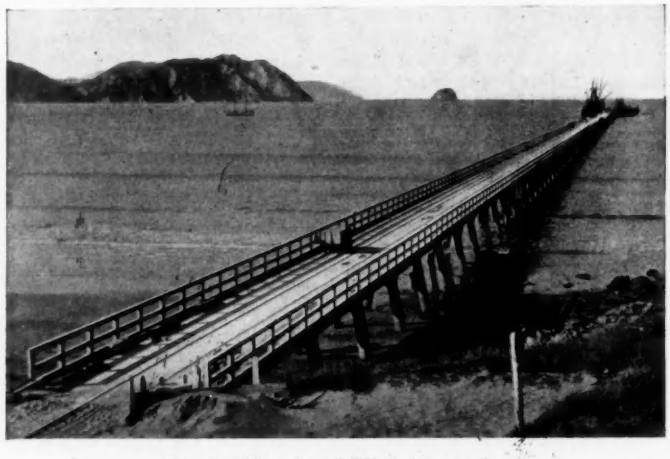

Fig. 2. Wharf and Piled Approach.

at Port Lyttelton, where the alignment of one of the wharves was altered by only 3½ degress during re-construction, with very appreciable improvement. This berth had been used by the largest overseas vessels visiting the port, but constant trouble had formerly arisen during those storms which caused any slight range in the harbour. The vessels developed a rolling pitch and broke their mooring-lines. The 3½ degree alteration to the alignment of the wharf (decided upon by Mr. Williams) overcame the trouble and the berth became one of the least disturbed in the harbour.

At Tolaga Bay it was decided to approach the problem of alignment of the wharf by imagining a ship at anchor in the bay and then putting a wharf alongside her. The first survey of the Bay was made by Captain James Cook in 1769, and his accurate little chart shows that, except for an alteration in the position of the river mouth, little change in the contours of the Bay has occurred since that date. Later soundings were taken by H.M.S. *Penguin* and a preliminary set of soundings over the area round the proposed site for the wharf was made before the preparation of designs for the structure. This proposed site for the wharf had of course to be that likely to give the most favourable alignment under all conditions of weather. Careful observations were made of the direction of approach of the largest waves, and the alignment of the wharf was finally determined as a result of the observations. The direction of the heaviest seas was fairly constant, as is quite common in partially enclosed bays. A study of the behaviour of the small craft carrying materials for the wharf as they lay alongside temporary fendering was of great help in solving this problem.

The floor of the bay shoals gradually, and in order to obtain a depth of 18 feet of water at low water of spring tides, the wharf had to be located at a distance of 2,000 feet from the shore. It had been assumed that no trouble would arise from reflected wave action, or from backwash from the shore, and that therefore there would be little tendency for the ships to develop fore-and-aft run, as so often happens at wharves close in to a steep shore or deep breastwork, where the tautening of lines, first forward and then aft, can render a vessel almost uncontrollable. In actual fact it was found at Tolaga Bay that light lines sufficed to hold the vessels to the wharf even when waves 3-4 feet in height from trough to crest were running. In this respect the most optimistic hopes were exceeded. It had been thought that substantial coir-rope "springs" might be necessary to hold the vessels at the wharf, but these are not essential. The results have surprised seafaring men with many years of experience of coastal shipping.

When the wharf was put into use it was at first usual practice for the ships to drop anchor before swinging into a berth where they would lie bow out to sea. As better knowledge of the site was acquired ships began to dispense with the anchoring and would run straight in and lie stern out to sea. Some saving in time was thus effected and, because of this simplicity in tying up, it became worth while for ships to call at the wharf to discharge even small consignments of cargo, so little time did they lose. During severe seas ships could lie away from the wharf and then return to it when conditions were calmer; but this might happen only a relatively few times in the year, whilst the practical effect on the quantity of cargo handled was inappreciable.

The Structure.

The structure consists of the piled approach to the wharf and the wharf proper at the outer end (Fig. 2). The *Teredo* is active in the waters of the bay and, as timber was known to have a comparatively short life, it was decided to build the wharf and approach of reinforced concrete. Temporary timber work exposed to attack during construction was destroyed in the course of 12-18 months. The life of Australian hardwood (chiefly Ironbark, charred and tarred where exposed to attack), which is used successfully in Lyttelton harbour, would probably have been relatively limited in Tolaga Bay.

The 2,000-foot approach consists of a reinforced-concrete deck 17 feet wide, with reinforced-concrete side rails, the deck, on caps and beams, being supported on pairs of raking piles 20 feet apart centre to centre (Fig. 3). The surface of the deck was 11 feet above high water of spring tides, or 17 feet above low water of spring tides. An expansion joint is provided in the deck of the approach portion at 1,100 feet from the shore, and the side railing is provided with joints at 100-foot intervals. At the outer end, in a length of 80 feet the approach widens out gradually to the full width (52 feet overall) of the wharf proper. Throughout the length of the wharf, which is 200 feet long, the caps are maintained at the 20-foot spacing, centre to centre, and are supported on four plumb piles and stiffened by two rakers in addition. Across the outer end of the wharf four extra rakers are driven to absorb some of the shock from waves breaking on to this part of the structure. The depth of water at the wharf was 24 feet at high water of spring tides or 18 feet at low water of spring tides.

It is a noteworthy feature of the construction that diagonal bracing and walings between piles above low tide-level were completely dispensed with, and stiffness was secured by the use of the bonded and capped raking piles only (Fig. 3). The whole is thus a rigid, fixed-ended portal frame with raking legs—very strong against forces in any direction and entirely monolithic: being without any vulnerable bracing members, the structure thus built offered the highest degree of strength combined with the minimum of wave resistance when subjected to the fierce storms that rage into the bay (Fig. 4).

Construction of Jetties in Exposed Roadsteads—*continued*

Timber "spring" fendering of Australian turpentine piles 5 feet apart centre to centre, and with four substantial 14-in. by 12-in. top longitudinal walings of ironbark, protects the wharf, turpentine being considered to be the most resistant wood so far as the *Teredo* is concerned. The piles were driven into holes drilled with an outward rake, the walings bolted behind them, and the fendering then chained back to the concrete structure, so that it exerted an outward thrust. This fendering proved

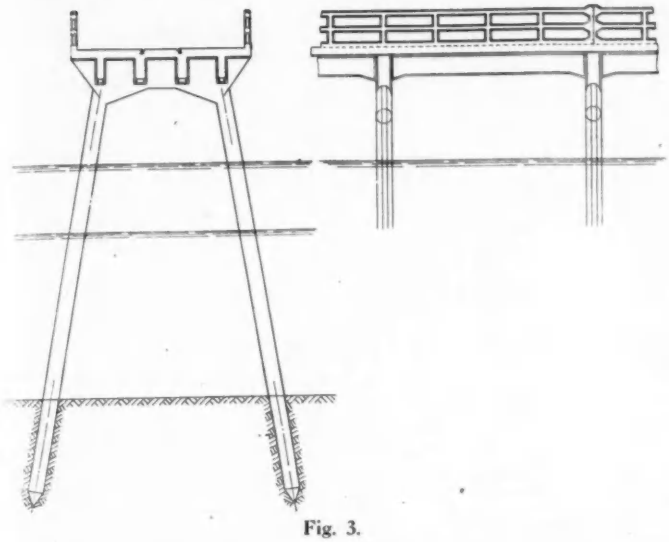

Fig. 3.

effective, absorbing the impact from ships shouldering up against it and then throwing them clear again before any effective weight was brought against the concrete. After several years of use the only repair work necessary was the replacement of three fender piles sheared off by a vessel that had approached the berth at too great an angle. Simple bollards of vertical cylindrical form were installed to facilitate the handling of mooring lines; and in order to prevent the ropes from riding over the collar and off the bollards, holes were drilled in the bollards through which short lengths of round bar can be placed when required.

A railway connects the wharf with the shipping-shed on shore, the rails being set flush with the concrete deck so that motor-vehicles can also use the wharf. On the wharf proper four parallel railway lines were installed, with a traverser set in a well at the outer end for shifting the wagons from one line to another.

Side-railing.—The side-railing was initially set out with 6-in. by 6-in. reinforced posts 5 feet apart centre to centre, and with three rails, also of 6-in. by 6-in. section, the lowest of which was set at deck-level. Later it was realised that cleaning of the deck surface would be facilitated by raising the bottom rail slightly to permit sluicing under it. A freshwater supply was provided by means of a 2-in. diameter pipe running to the end of the wharf, and take-off cocks at convenient points provided an effective and easy means of washing the concrete surface, which was especially necessary after loading livestock. As such a jetty would not be complete without signalling equipment, yardarm wes erected at the seaward end of the wharf for communicating with vessels entering the bay.

Shipping Arrangements.

A shipping shed, timber framed and sheeted with corrugated steel sheeting, was constructed on shore alongside the railway leading on to the jetty. Except for livestock, most inward and outward cargoes pass through this shed. Wool, which provides the main export trade of the district, is usually collected from the farms by lorry and stored in this shed prior to shipment to the wool sales at Napier. Sometimes it is shipped abroad, in which case the larger overseas ships lie out in the bay and are lightered by the coastal vessels, which can make quick trips between the large ships and the jetty, where they are loaded from railway trucks or lorries with the aid of their own cranes.

The floor of the shipping shed is arranged at the level of the floor of the railway trucks, whilst the roadway which serves the opposite side of the shed is formed at a level which allows the lorries to back up to the sliding doors with their floors level with that of the shed. Handling of the cargoes through the shed is effected by hand trucks and mobile cranes.

Next to wool the other important outward freight is livestock, consisting of breeding ewes for the Waikato and Auckland districts, most of which are shipped to Tauranga. Between 15,000 and 20,000 were being shipped each year. Before the completion of the jetty, sheep from the district were taken a two or three days journey by road to the nearest port. During this time the sheep lost in condition, so that they were then less able to stand up to the sea voyage which followed. In contrast, the wharf at Tolaga Bay provides a good loading depot, for good fields and pasture are available in the vicinity of the wharf, where the sheep can be collected and held to await shipping. The long parapeted approach also forms a useful pen, and, after travelling this approach, the sheep follow along the gangways on to the ships with the minimum of trouble. Thus sheep or cattle loading operations can be expeditiously carried out.

Construction

The first ten bays of the approach, extending out from the shore to low-water mark, were constructed on piles built in situ in holes cut into the rock bottom, which underlies the sand. This initial length of about 200 feet, when decked, formed a convenient platform on which to construct the pile-driving plant and from which to commence operations.

So quickly do storms arise on this unprotected coast, and so usual is some degree of wave motion, even in fair weather, that it was decided to dispense as much as possible with floating plant and to carry the drilling and pile-driving gantry out over the reinforced-concrete piles as they were driven. The gantry (Fig. 5) was arranged to travel upon rails fixed directly to

Fig. 4. Action of Waves on the Piles in a Storm.

Oregon timber beams, the ends of which rested on the timber walings bolted across the tops of each pair of piles. A second system of beams and walings was arranged at a lower level for the support of the falsework for concreting the caps, beams, and deck, but in the meantime this provided part of the support for the weight of the gantry. Even so, it was important to restrict the weight of the gantry to the minimum. This enabled the weight and size of the supporting baulks to be kept within

Construction of Jetties in Exposed Roadsteads—continued

easy handling proportions, because all this material had to be man-handled from one position to the next as each forward move was made.

Timber for the construction of the gantry was cut from the bush near Gisborne and floated by river to the sea, where it was picked up for transport by boat to Tolaga Bay. Lengths of about 56 feet were required for the main longitudinal members of the gantry, which were formed from two fine straight blue-gum trees. Upon these timbers the gantry was built in the form of a cantilever with an A-framed set of leaders capable of being supported 24 feet beyond the end of the substructure. Steam winches and a boiler were arranged at the tail of the gantry to provide the counter-weight while the gantry was being travelled from one position to another. From the top of a strong-back rigged amidships, wire rope stays lead down to the fore and aft ends of the main longitudinal members. The sloping leaders were constructed as an A-frame set normal to the line of travel, and were supported at the end of the cantilever.

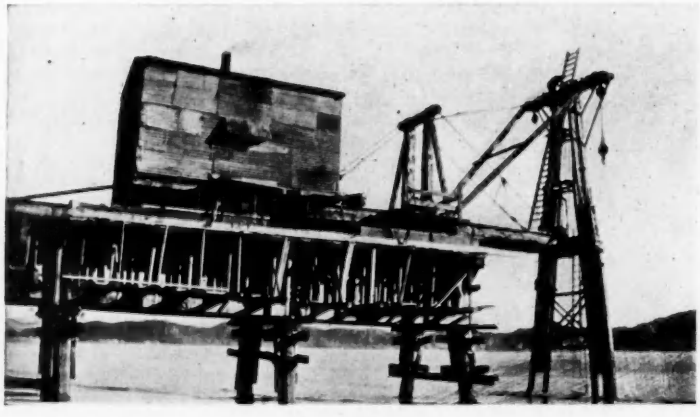

Fig. 5. Gantry.

Spud-legs were provided at the sides of each set of leaders to run in guide brackets fitted with a clamping device. These were capable of being lifted during travel and heaved down to bear on the sea-bed, where they could be clamped in position for heavy lifting work. Across the top of the leaders a head-piece projected well out to support tackle arranged conveniently for lifting heavy work, by means of which lifts of 10 tons could be handled.

From the winches the usual single whip led through sheave-blocks to the leaders, whilst the three-fold lifting tackle was controlled from the second winch-drum. The gear was duplicated for the second set of leaders, so that it was necessary to run on to the two winch-drums, whichever sets of gear had to be used. This was easily accomplished and the experienced team of men engaged upon the piling work made the changes quickly. Small hand winches, mounted on outrigger platforms at the sides of the gantry, were used for manipulating the spud-legs.

The gantry was constructed on the first length of completed structure with the A-framed leaders erected over the end of the concrete deck previously completed. It was then run out so that the leaders were in the required position for driving the first pair of piles. The holes were usually sunk 11 feet deep into the rock, as later described, and the piles were pitched and driven. The gantry was then run out to a slightly more forward position with the leaders clear of the piles, so that the walings could be bolted across the piles and the timber beams and rails secured upon them before the gantry was moved to the next driving position. This procedure was repeated until the piling was sufficiently far advanced to allow the building of the superstructure to commence.

When driven, the pile-heads were approximately at deck-level. Although this gave a longer pile than was actually necessary for the structure, it allowed the temporary work to be kept at a level sufficiently high to ensure that the gantry would be above the reach of the heaviest seas. The piles, 19 inches in diameter, were cast in steel segmental moulds clamped to 6-in. wide wooden bases, whilst a 6-in. width of opening was provided along the top for pouring the concrete. Thus 6-in. wide flats were formed on opposite sides of the piles, which otherwise were circular in section. Eight $1\frac{1}{8}$-in. diameter mild-steel rods were used for the main reinforcement, with diaphrams of $\frac{3}{8}$-in. diameter rods 4 feet apart centre to centre and No. 8 gauge black binding wire along the length of the pile. Additional wire was introduced at the heads to withstand the driving, and typical wrought-steel pile shoes of usual form were used.

At first the piles were cast on shore, seasoned for eight weeks, and rolled down the beach, whence they were hauled out to the gantry by a wire rope from one of the winches. As the work progressed the piles were cast along the deck of the approach, trucked out to a stiff-legged derrick, and lowered over the side. For transport to the gantry a float was used. This was small enough to be able to be easily lifted on to the deck and stored there when not in use, but sufficiently buoyant to support the 7-ton piles suspended in wire strops under it whilst still leaving about 12 inches of freeboard. A certain degree of leakage into the float took place, but it was found that six piles could be carried out before it was necessary to lift the float out of the water for draining. The round form of the piles proved convenient for all operations. It allowed the pile to roll in the strops and to centre itself while being carried, and also facilitated handling into the leaders. The only floating plant found necessary on the work was the float just described and a small dinghy.

For driving the piles in the wider widths of the wharf, and after completion of the approach, the gantry was reconstructed. In order to obtain complete widths of the wharf superstructure the gantry was designed for driving the six piles across each bay as it progressed. The central pair of piles were driven in advance by a pair of plumb leaders cantilevered forward as before, whilst the raking and outside plumb piles were driven from leaders rigged amidships of the gantry as the respective sets came into the required positions during the forward travel of the gantry. Single leads for the drilling and driving, and three-fold sets of heavy lifting gear, were provided at each of the six sets of leaders. The connection of the required sets to the winches was quickly effected.

As the piles were driven in the approach and in the wharf structure efforts were immediately made to secure each set of piles by attachment of cross-walings and longitudinal beams, whilst "needles" were cut in behind the new pile-group to provide support from the completed structure. Despite the speed with which this was usually done, it often happened that storms arose so quickly that damage resulted before the piles could be secured; and as the storms reached their height it usually became impossible to venture beyond the end of the completed structure, even to secure connections that might be working loose. Thus the work might have to be left to the mercy of the constant battering of the seas—possibly for two days.

After such storms examination would sometimes show that one or more of the piles supported by the temporary falsework, as described, had worked loose and been fractured at or below ground-level. The extraction of these damaged piles proved to be one of the most difficult operations to be performed. Apparently, after the piles were driven, sand rilled down between the pile and the rock and so cemented the pile into the hole that no gear available on the work was sufficiently powerful to withdraw the pile. It was found necessary to drill another hole alongside the fractured pile and to shatter it with a charge of explosive before the steel rods could be withdrawn. As the work progressed greater proficiency was acquired in securing the piles against storms, but no weak link ever survived the severe test of a storm.

The finished structure was designed to present as little obsruction as possible to the run of the seas, but, during construction

Construction of Jetties in Exposed Roadsteads—continued

a considerable quantity of false work and boxing had to be built within reach of the waves during storms. As it could not be hoped to make this withstand the action of the waves (Fig. 4), it was put together so that, until filled with concrete, it could be quickly and easily washed clear of the structure, leaving only the supporting piles to be exposed to the seas.

Caps, beams, and deck slab were cast in suit because of the inability to predetermine exactly the position of pile-heads after driving. The possibility of using pre-cast members to reduce the falsework to the minimum was considered, but it was thought that better results were obtained by casting in situ.

The concreting of the superstructure at suitable times proved a comparatively simple problem because, with prospects of fine weather, several bays could be completed and the concrete would have time to acquire a set and some maturity before the weather broke. Forecasts of bad weather were promptly sent to the works by the local Post Office officials and preparations to "batten down" for a storm were thus often able to be made long before any indication of a change of conditions was evident at the site.

Tidal Waves.

New Zealand is a volcanic country and has frequent seismic disturbances. On one occasion considerable damage resulted from three large tidal waves which ran into the bay. Five piles had been driven and were being secured when the approach of the waves was noticed. It was immediately apparent that they were of unusual size, although the waters of the bay had been only slightly roughened by a moderate easterly breeze. The Author was able to view the spectacle from the top of the pile plant. The waves had begun to break before they reached the frame and it was difficult to determine their exact height, but pile-heads were submerged in green water so that the wave crests were running at least at deck-level which, as already stated, is 11 feet above high water of spring tides (Fig. 6).

The impact, as the first wave struck the pile frame, was considerable. The five unsecured piles were fractured and the lower ends of the leaders of the pile frame and all loose timber were swept away. The gantry, although chained and wedged out into position, was pushed backwards and, from the Author's precarious position on the platform, it appeared as though the whole frame was collapsing. Luckily the destructive force of the succeeding waves was less and little further damage resulted. The work of repairing plant and redriving piles after the damage, which was caused in a few minutes without much warning, occupied several weeks.

Drilling.

The bottom of the bay was of tough mudstone, overlain in places by several feet of sand, and it proved necessary to drill holes for all pile positions, as it was impossible to drive the piles into the mudstone. For this work a discarded set of oil-well drilling gear was obtained in the district and adapted for use at the jetty side.

The drill, which was of the jumper type, consisted of a cutting bit and length of 4-in. diameter steel shafting, to which the operating wire rope was secured by shackle and swivel which permitted free rotation of the drill. At first the connection beween the shafting and bit was made by a threaded quick-taper joint. This proved unsatisfactory for the drilling of raking holes and was altered to a parallel threaded connection secured with a locking key. The bit of the drill was of oval section, about 9 inches by 6 inches, with grooves down the 9-in. side for 4 feet of its length and then flattened out to form the cutting portion, which extended for a further 1 foot of length and provided a flat cutting-face 22 inches by 1½ inch. As it rotated and chipped out the rock by repeated percussion, the 22-in. width of cutting-blade produced a hole in which the piles were a comfortable sliding fit. Wear of the cutting-blade, which showed in the form of rounding of the outside corners and wearing away of the cutting-face to an edge, reduced the efficiency of drilling. For the drill to cut evenly, clearly, and quickly, it was necessary for the bits to be maintained in good order and, for this reason, three sets were used so that a reset bit was always available for replacement immediately the one in use became difficult to operate. This happened when the worn cutting-edge began to cut narrow grooves, resulting in a tendency for the drill to jam in the holes. Moreover, as the cutting width narrowed through the outer corners becoming rounded, the effort required to drive the piles increased. Therefore it was of the greatest importance to keep the drilling equipment under careful supervision and to ensure that the drills were in good order. Before the full importance of this was realised considerable time was lost in persevering with worn drills which, besides cutting badly, failed to rotate evenly until they finally jammed in the holes being drilled. On a few occasions, the bits became detached from the shaft and were left at the bottom of the holes, from which their recovery was very difficult. Usually the drills rotated freely, but sometimes it was necessary to have a man using a rope with a turn round the shaft who could control the rotation. Hard round "plumbs" in the mudstone, when they occurred to one side of the hole, disturbed

Fig. 6. Action of Waves on Piles.

even drilling and presented something of a problem that was not satisfactorily solved on this work. Some special bits, acquired with the drilling gear, which looked as though they might have been designed for such contingencies in oil-well practice, were tried out on this work, but without success, and forceful methods with the ordinary drills were resorted to. Failing this, in very refractory cases the obstacle was blazed away with gelignite. The Author had, not infrequently, to make an examination of the state of affairs in a diving suit—the only satisfactory way.

The hardness of the rock varied considerably throughout the length of the jetty, and it had been hoped that some of the piles might be able to be driven into position, but this was not possible. The time required for drilling the 11 foot deep holes ranged from 45 minutes to 8 hours.

Steam friction winches proved very satisfactory for operating the drill, which travelled in roller-guides set in the leaders. The height of fall preferred by the drillers ranged from 12 feet to 16 feet. This was considerably in excess of that understood to be usual for operating large jumper drills in oil-wells. However, the gear withstood this heavy usage and the only trouble experienced—a minor one—was with the swivel connection between the shaft and the wire rope. At first a fairly substantial unit was used in this position, but it was found that excessive weight was a particular disadvantage, because this increased the impact and hammering effect on the link when the drill was suddenly stopped in its downward travel as it struck the rock. The lightest shackle and swivel that could withstand the initial lift of the 26-cwt. drill proved the most satisfactory. At first it was thought that, where sand of appreciable depth was encountered above the rock, difficulties would be experienced with the drilling, and some consideration was given

Construction of Jetties in Exposed Roadsteads

(continued)

to possible means of maintaining open holes until the piles were in position. Resistance to drilling from sand lasted for only a few blows, after which the drill could be heard ringing against the rock. As the cutting proceeded the pulverized rock was expelled from the holes by the pump-like action of the drill and interspersed among the sand-particles so that they actually became firmly cemented for some distance out from the holes. The crater-shaped entrance to the hole that resulted proved helpful in centering the pile-shoe into the hole, and a problem that caused much concern before the work began did not arise.

Conclusion.

With the recent danger to New Zealand and Australia of invasion from the sea, the Author feels that now only is the time safe to call attention to the technical merits of this particular jetty; but, just as such a jetty may have been an asset to a venturesome enemy wishing to land upon our territories, so it is equally possible to improvise similar forms of wharves and jetties based on similar principles for landing upon Axis territory at points where there may be no fully-enclosed natural harbours, yet favourable tactical opportunity.

Further it is felt that Mr. Williams' rather daring project at Tolaga Bay deserves recognition as an outstanding harbour engineering achievement in the design of open-roadstead jetties.

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Port and City of Hull

Development Proposals

In a report prepared by the Chamber of Commerce and Shipping of Hull and presented to the Corporation Reconstruction Committee for discussion at the end of May under the chairmanship of the Lord Mayor, various proposals were put forward for the replanning of the City and Port in fulfilment of commercial and industrial requirements.

The report stated that, so far as the local authority was concerned, the Chamber emphasised the need for space adjacent to the docks, the need for improved approaches to dock premises, and the importance of the Old Harbour and of the River Hull. As regards the western and town docks, roughly one-quarter of the tonnage using the port consists of coasting or small type vessels and nothing must be done calculated to impair the accommodation for these vessels.

Alleged Congestion

Railway-owned, the Hull docks (the report continued), were not and have not been laid out to cater for the development of road transport. This resulted in congestion and restrictions, the causes of which must be removed for Hull to own its own in competition with non-railway owned ports.

" The provision of dock sites for industry, with the necessary rail and road connections, is essential, especially if post-war conditions are favourable to an enlarged reciprocal trade with the Continent. Important units of the flour milling industry, for example, have suffered severely. Their reinstatement is a matter of serious concern, and modern conditions demand the location of mills alongside deep water. Similar conditions apply to other industries."

Reviewing Prof. Abercrombie's proposals, which were stated to provide for a clearance of the land between Hessle Road and the docks, the setting aside of an area in the vicinity of the Radiator Works, the zoning of both banks of the River Hull from Stoneferry to Scott Street Bridge, and a belt running parallel with the eastern docks as far as Marfleet, the Chamber in their report considered that the suggestion to deindustrialise the most valuable section of the Old Harbour to be ill-conceived and reflecting insufficient knowledge and apprecation of local needs, in that the deepest stretch of the river would, in the course of time, be withdrawn from commercial use.

The Old Harbour.

" One of the essential features of Hull," said the report, " is the River Hull. The natural advantages presented by the Old Harbour were the very factors which determined the origin and site of the port. As an overside port, those factors are as true to-day as of yesterday. Hull is first and foremost one of the greatest seaports, and it is very necessary that this practical and realistic fact should be recognised. Hull is also the hub of a vital water carriage system which connects to the West Riding, Nottingham, and other places. Many of these services radiate from the Old Harbour."

Urging that the great need after the war will be full employment, and that the means of livelihood must take precedence over the problematical attractions of amenities, the Chamber suggested that instead of deindustrialisation, it was urgent that steps should be taken to make the lower reaches of the river even more attractive to commerce and industry, with no break between the eastern and western dock systems.

River Front Heritage

Asked if they were recommending that the whole of the river frontage should be reserved for commercial purposes, Mr. W. Fenton, president of the Chamber of Commerce, said they were strongly of that opinion. They considered that the commercial interests of the port, which were those of the citizens, were paramount.

The Lord Mayor rejoined that people of Hull regarded the river front as part of their heritage. If they were to industrialise the whole of the river front from the Fish Dock to the village of Paull, a stretch of seven miles, they would be doing a great disservice to the citizens. Some part of the river front between those two points must be open to the public.

The report of the Chamber went on to say that by natural sequence Hull had broadly developed in the past in the form of an inverted " T," formerly on the vertical and latterly on the horizontal lines of the letter; that design should be maintained intact with provision for broader industrial and commercial belts running the length of the Humber frontage and of the River Hull as far north as the existing Stoneferry area. Every facility must be extended to old-established firms to modernise and extend their premises to meet post-war conditions.

The Fishery Industry.

Starting from west to east, the suggestion had been made, the report further stated, that the land south of Hessle Road should be cleared. The fishing industry required more water space and a wider dock; market processing and distribution facilities required more land north of the dock; and ancillory businesses had been obliged to set up in remote areas because of the lack of room. It at once became doubtful whether the space to be provided was adequate, especially having regard to the needs of established industries in the same area unconnected with fishing.

The river frontages along the west bank of the River Hull should be widened by setting back the roadways as part of a long term policy, and the same remarks applied to certain sections of the roadways on the east bank. The position at the eastern docks was not dissimilar to that of the Fish Dock. The war-time practice had been to disperse timber to points outside the port area and nearer to consuming centres. The result had been to develop saw mills in the Midlands and West Riding, and unless facilities were provided whereby timber might be processed more cheaply in the port, the retention of this important avenue of employment will be difficult.

A proposal to form a sub-committee to act in an advisory capacity was not carried, but it was agreed to send a copy of the Chamber's report to Professor Abercrombie, who is responsible to the City Council for the preparation of the plans.